

A Review Paper on Design & Analysis of Leaf Spring

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Abstract--This paper reviews some of the general study on the design, analysis and fabrication of composite leaf spring. Leaf springs are one of the oldest suspension components they are still frequently used, especially in commercial vehicles. The literature has indicated a growing interest in the replacement of steel spring with composite leaf spring. The suspension system in a vehicle significantly affects the behavior of vehicle, i.e. vibration characteristics including ride comfort, stability etc. Leaf springs are commonly used in the vehicle suspension system and are subjected to millions of varying stress cycles leading to fatigue failure. A lot of research has been done for improving the performance of leaf spring. Lot of materials are used for leaf spring .but it is found that fiberglass material has better strength characteristic and lighter in weight as compare to steel for leaf spring. In this paper the author is reviewed few papers on use of alternate materials and effect of material on leaf spring performance.

Keywords: steel leaf spring, ANSYS, PRO-E software.

I. INTRODUCTION

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. The main function of leaf spring assembly as suspension element is not only to support vertical load, but also to isolate road-induced vibrations. The behaviour of leaf spring is complicated due to its clamping effects and inter-leaf contact etc. It carries lateral loads, brake torque, driving torque in addition to shock absorb. Springs are crucial suspension elements on cars, necessary to minimize the vertical vibrations, impacts and bumps due to road irregularities and create a comfortable ride. 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 unsprung weight. 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. In the design of springs, strain energy becomes the major factor. In the present scenario the main focus of automobile manufacturers is weight reduction of the automobile. Weight reduction can be achieved mainly by introducing the better material, design optimization and better manufacturing processes. In automobiles, leaf spring is one of the potential parts for weight reduction as it accounts for 10% - 20% of the unsprung weight. Composite materials

have made it possible to reduce the weight of leaf spring without any reduction in load carrying capacity and stiffness. Composite materials are now used extensively in place of metal parts. Several papers were devoted to the application of composite materials for automobiles.

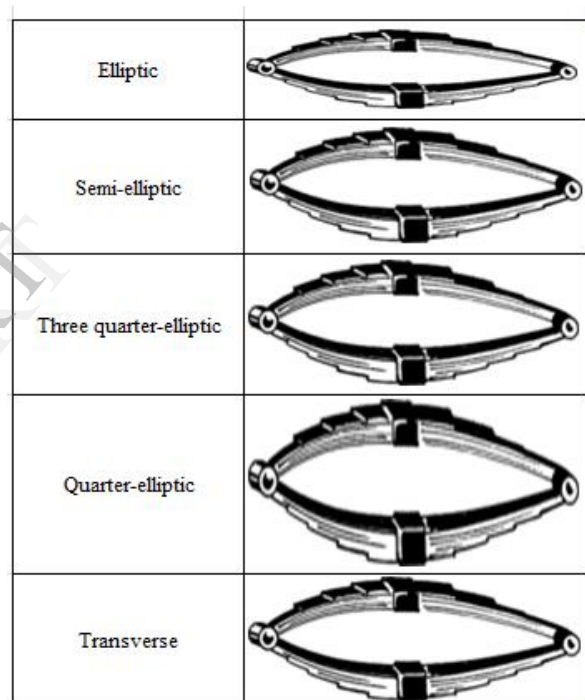


Figure 1.1 Types of leaf spring

The figure shows a laminated semi- elliptic spring. The top leaf is known as the master leaf. The eye is provided for attaching the spring with another machine member. The amount of bend that is given to the spring from the central line, passing through the eyes, is known as camber. The camber is provided so that even at the maximum load the deflected spring should not touch the machine member to which it is attached. The central clamp is required to hold the leaves of the spring.

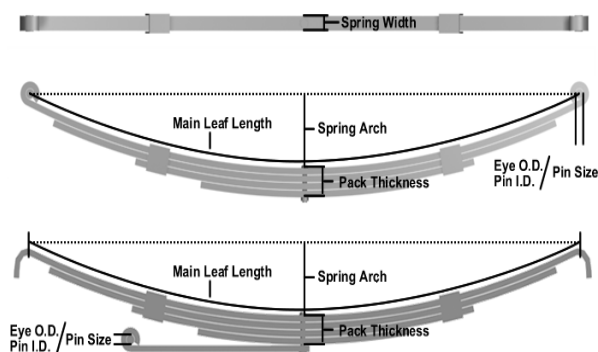


Figure 1.2 Laminated semi-elliptical leaf spring

II. LITERATURE REVIEW:

In this section research papers are discussed related to the present work. Published papers are highlight in this section.

Mahmood M. shokrieh and Davood Rezaei^[1] presented work on design, analysis and optimization of leaf spring. The aim of this review paper was steel leaf spring was replaced with an optimized composite one. Main objective of this paper was to obtain a spring with minimum weight that is capable of carrying given static external forces without failure. Here the work is carried out of a four-leaf steel spring which used in the rear suspension system of light vehicles & heavy duty vehicles. The four-leaf steel spring is analyzed by using ANSYS V5.4 software. The finite element results showing stresses and deflections verified the existing analytical and experimental solutions. Using the results of the steel leaf spring, a composite one made from fiberglass with epoxy resin is designed and optimized using ANSYS. Main consideration is given to the optimization of the spring geometry. In this study stress and displacements were used as design constraint. The experimental results are verified with the analytical data and the finite element solutions for the same dimensions. Result shows that stresses in the composite leaf spring are much lower than that of the steel leaf spring. Compared to the steel leaf spring the optimized composite leaf spring without eye units weights nearly 80% less than the steel spring. The natural frequency of composite leaf spring is higher than that of the steel leaf spring and is far enough from the road frequency to avoid the resonance.

E. Mahdi a, O.M.S. Alkoles^[2] etc presented work on light composite elliptic springs for vehicle suspension. They worked on based study marries between an elliptical configuration and the woven roving composites. In this paper, the influence of ellipticity ratio on performance of woven roving wrapped composite elliptical springs has been investigated both experimentally and numerically. A series of experiments was conducted for composite elliptical springs with ellipticity ratios (a/b) ranging from one to two. Here they were also presented history of their failure mechanism. Both spring rate and maximum failure increase with increasing wall thickness. In general, this present investigation 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.

Y. N. V. Santhosh Kumar, M. Vimal Teja^[3]

etc presented work on design and analysis of composite leaf spring. They also discussed the advantages of composite material like higher specific stiffness and strength, higher strength to weight ratio. This work deals with the replacement of conventional steel leaf spring with a Mono Composite leaf spring using E-Glass/Epoxy. For this they selected design parameters and analysis of it. Main objective of this work is minimizing weight of the composite leaf spring as compared to the steel leaf spring. For this they selected the composite material was E-Glass/Epoxy. The leaf spring was modeled in Pro/E and the analysis was done using ANSYS Metaphysics. From results they observed that the composite leaf spring weighed only 39.4% of the steel leaf spring for the analyzed stresses. So from result they proved that weight reduction obtained by using composite leaf spring as compared to steel was 60.48 %, and it was also proved that all the stresses in the leaf spring were well within the allowable limits and with good factor of safety. It was found that the longitudinal orientations of fibers in the laminate offered good strength to the leaf spring.

Pankaj Saini, Ashish Goel, Dushyant Kumar^[4] etc. studied on design and analysis of composite leaf spring for light vehicles. Main objective of this work is to compare the stresses and weight saving of composite leaf spring with that of steel leaf spring. Here the three materials selected which are glass fiber reinforced polymer(E-glass/epoxy),carbon epoxy and graphite epoxy is used against conventional steel. The design parameters were selected and analyzed with the steel leaf spring. From results, they observed the replacement of steel with optimally designed composite leaf spring can provide 92% weight reduction and also the composite leaf spring has lower stresses compared to steel spring.. From the static analysis results it is found that there is a maximum displacement of in the steel leaf spring. From the result, among the three composite leaf springs, only graphite/epoxy composite leaf spring has higher stresses than the steel leaf spring. From results its proved that composite mono leaf spring reduces the weight by 81.22% for E-Glass/Epoxy, 91.95% for Graphite/Epoxy, and 90.51 % for Carbon/Epoxy over steel leaf spring. Hence it is concluded that E-glass/epoxy composite leaf spring can be suggested for replacing the steel leaf spring from stress and stiffness point of view.

Manas Patnaik, Narendra Yadav^[5] etc worked on study of a parabolic leaf spring by finite element method & design of experiments. Main objective of this study was the behaviour of parabolic leaf spring, design of experiment has been implemented. For DOE, they selected input parameters such as Eye Distance & Depth of camber. This work is carried out on a mono parabolic leaf spring of a mini loader truck, which has a loading capacity of 1 Tonnes. The modelling of the leaf spring has been done in CATIA V5 R20. Max Von Mises stress and Max Displacement are the output parameters of this analysis. In DOE Eye Distance & Depth of camber have been varied and their affect on output parameters have been plotted. The variation of bending stress and displacement values are computed. From design of experiments they observed

following a) If The camber is increased there is a decrease in the average amount of displacement. b) If the eye distance is increased there is an increase in the average amount of displacement. c) If the camber is increased there is an increase in the average amount of von mises stress. d) If the eye distance is increased there is an increase in the average amount on von mises stress.

Hence from results it is conclude that the optimum setting of dimensions pertaining to parabolic leaf spring can be achieved by studying the various plots obtained from Design of Experiments.

Malaga. Anil Kuma, T. N. Charyulu,^[6] etc presented work on design optimization of leaf spring. The automobile industry has shown increased interest in the replacement of steel spring with composite leaf spring. Main purpose of this paper is to replace the multi-leaf steel spring by mono composite leaf spring for the same load carrying capacity and stiffness. Composite materials have more elastic strain energy storage capacity and high strength-to-weight ratio as compared to those of steel. It is possible to reduce the weight of the leaf spring without any reduction on load carrying capacity and stiffness. The design constraints were limiting stresses and displacement. Here the dimensions of a leaf spring of a light weight vehicle are chosen and modeled using ANSYS 9.0. As the leaf spring is symmetrical about the axis, only half part of the spring is modeled by considering it as a cantilever beam. Three different composite materials have been used for analysis of mono-composite leaf spring. They are E-glass/epoxy, Graphite/epoxy and carbon/epoxy. Static and model analysis has been performed. From results it is concluded that E-glass/epoxy has lower stresses among using three materials. So they suggested E-glass/epoxy composite material for replacement of steel leaf spring.

Prahalad Sawant Badkar^[7] worked on Design improvements of leaf Spring of BEML Tatra 815 VVNC 8 X 8 Truck. Main objective of this work is increase the PL carrying capacity of BEML Tatra by 5000 kg. by incorporating the necessary changes in suspension system(Leaf Spring) of the vehicle. The distribution of gross vehicle weight (GVW) on the front and rear tandem axles are Front axle weight is 2 x 6500 kg , Rear axle weight is 2 x 7500 kg , Gross vehicle weight is 28,000kg . Here they do some changes in design so they distributed weight of of Fifth wheel load (FWL) on the front and rear tandem axle is Front axle weight is 2 x 6750 kg, Rear axle weight is 2 x 9750 kg ,Gross vehicle weight is 33,000 kg . The new design of rear leaf spring, stress vehicles for rated load and maximum load are well within the yield stress of material. The new design rear leaf spring also gives the higher fatigue life this is most important in design of any leaf spring, this helps in measure the life of spring. Results showed that finite element analysis (FEA) on rear leaf spring verifies that, design were adequate. The material 60Cr4V2 is better for design of new leaf spring, which fulfills the requirement.

H.A.AI-Qureshi^[8] studied on automobile leaf spring from composite materials. The aim of this paper is design, analysis & fabrication of composite spring. For this compact car is taken as prototype. A single leaf, variable thickness spring of glass fiber reinforced plastic with similar mechanical and geometrical properties to the multileaf steel spring was

designed, fabricated and tested. Here they performed experiment in laboratory & was followed by road test. Field testing to determine ride characteristics were also carried out on a number of GFRP spring which were mounted in place of conventional steel spring on jeep. This test were limited to ride quality and sound observation on different road condition. From result it is observed that GFRP spring were more flexible then steel leaf spring. From test ride they observed that harshness & noise also reduced then steel leaf spring. Compared to the steel spring, the optimized composite spring has stresses that are much lower, the natural frequency is higher and the spring weight without eye units is nearly 80% lower.

Ashish V.Amrute, Edward Nikhil karlus,^[9] presented work on design & assessment of leaf spring. Main objective of this work is to compare the load carrying capacity, stresses and weight savings of composite leaf spring with that of steel leaf spring. Here the multi leaf spring consist three full length leaves in which one is with eyed ends used by a light commercial vehicle. For analysis of leaf spring Tata ace ex vehicle taken as prototype. This work deals with replacement of conventional steel leaf spring of a light commercial vehicle with composite leaf spring using E-glass/Epoxy. Dimensions of the composite leaf spring are to be taken as same dimensions of the conventional leaf spring. The Theoretical and CAE results are compared for validation. From results it is proved that the bending stresses are decreased by 25.05% in composite leaf spring means less stress induced with same load carrying conditions. The conventional multi leaf spring weights about 10.27kg whereas the E-glass/Epoxy multi leaf spring weighs only 3.26 kg. Thus the weight reduction of 67.88% is achieved by using composite material rather than using steel material.

III. CONCLUSION

From the literature review it is seen that the objective was to obtain a spring with 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 composite leaf spring. Composite leaf spring is better than using steel leaf spring. The performance of steel leaf spring was compared with the composite leaf spring using analytical and experimental results. FEA are used for prediction about the total life cycle and fatigue life of composite and steel leaf spring. Results show that the composite leaf spring is lighter than conventional steel leaf 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 the steel leaf spring and is far enough from the road frequency to avoid the resonance. The stresses in the composite leaf spring are much lower than that of the steel spring. Composite materials have more elastic strain energy storage capacity and high strength to weight ratio as compared with those of steel therefore, it is concluded that composite leaf spring is an effective replacement for the existing steel leaf spring in automobile.

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