

STUDY OF COMPOSITE AS AN ALTERNATIVE MATERIAL FOR LEAF SPRING: A REVIEW

¹Mahesh A. Khot, ²Atul Talape, ³Swapnl Chandgude, ⁴Pankaj Katre, ⁵Rohan Kare
^{1,2,3,4,5} Assistant Professor

^{1,2,3,4,5} Mechanical Engineering Department,
^{1,2,3,4,5} JSPM's Imperial college of Engineering & Research, Wagholi, Pune, India

Abstract- Now a days, advanced composite materials offer significant advantages in strength and stiffness, which can be achieved along with light weight, relative to conventional metallic materials. Modern composites using fiber-reinforced matrices of various types have created a revolution in high-performance structures in recent years. Leaf springs are one of the oldest suspension components in the automobile industry and they are still frequently in use. The current leaf spring is multiple leaf spring types with a steel material. It has high weight, low natural frequency, high corrosion, more noise and the property of material is changing when the load is acting, therefore current multiple leaf spring needs to be changed. Due to this, the automobile industry has also shown more interest in the replacement of steel spring with composite leaf spring.

This paper contains study of leaf spring which is made by steel material and different composite materials. The comparison of properties of steel material and composite material shows that replacement of steel leaf spring with composite material can be done. Composite material offers significant advantages as like more strength, less weight and hence more strength to weight ratio, more natural frequency, etc.

Index Terms —*Leaf spring, Steel material, Composite material*

I. INTRODUCTION TO LEAF SPRING

Leaf spring are one of the oldest suspension component they are still frequently used. Leaf spring was first used in 1804 by Obadiah Elliot for suspending the horse drawn cart. It was then incorporated in early designs of motor vehicles. Weight reduction is termed important in recent times in automobile industry as it saves material as well as energy. Commonly steel leaf springs fail suddenly, which increases possibility of accidents of vehicle due to leaf spring failure.

The current leaf spring is multiple leaf spring types with a steel material. It has high weight, low natural frequency, high corrosion, more noise. Therefore current multiple leaf spring needs to be changed replaced. In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturers in the present scenario. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. The suspension leaf spring is one of the potential items for weight reduction in automobiles as it accounts for 10% - 20% of the unsprung weight. This achieves the vehicle with more fuel efficiency and improved riding qualities. The introduction of composite materials was made it possible to reduce the weight of leaf spring without any reduction on load carrying capacity and stiffness.

II. INTRODUCTION TO COMPOSITE MATERIALS

Composite material is a material made up of two or more constituents combined together by mechanical or chemical bonds. In composite materials constituents tend to retain their original physical properties. Many composite materials are known to have superior structural performance when compared with the conventional materials. They are generally superior when it comes to strength to weight ratio and so are sought as a replacement of the steel in many applications.

Composite materials are ideal for structural application where high strength to weight and stiffness to weight ratio are required. Aircraft and spacecraft are typical weight sensitive structures in which composite materials are cost effective. These materials are basically hybrid materials formed of multiple materials in order to utilize their individual structural advantages in a single structural material. The composite material then has the properties of the two materials that have been combined. The advantage of composite materials is that, if well designed, they usually exhibit the best qualities of their components or constituents and often some qualities that neither constituent possesses. Some of the properties that can be improved by forming a composite material are

Strength	Fatigue life	Stiffness
Corrosion resistance	Thermal insulation	Weight
Wear resistance	Attractiveness	Thermal conductivity
Acoustical insulation		

Naturally, not all of these properties are improved at the same time nor is there usually any requirement to do so. In fact, some of the properties are in conflict with one another, e.g., thermal insulation versus thermal conductivity. The objective is merely to create a material that has only the characteristics needed to perform the design task. Modern composites using fiber-reinforced matrices of various types have created a revolution in high-performance structures in recent years. Advanced composite materials offer significant advantages in strength and stiffness coupled with light weight, relative to conventional metallic materials. Along with this structural performance comes the freedom to select the orientation of the fibers for optimum performance. Modern composites have been described as being revolutionary in the sense that the material can be designed as well as the structure.

The Automotive industry has been a major factor in the development and application of composite material. By weight, about 8% of today's automobile parts, including bumpers, body panels and doors are made of composites. Ceramic composite engine which would not require water-cooling. Chopped glass fiber-reinforced polymers have been used extensively in body panels, where stiffness and appearance are the principal design criteria. The usual design criterion for composite material is based on trying to align the fibers with most critically loaded directions of mechanical component. It is very important to design the composite material by arranging fiber orientation and volume fraction which gives optimum results at low cost and low weight. Optimized design needs to be checked by using experimentally as many times theoretical and finite element approach for these may not give true results.

III. LITERATURE SURVEY

Mahmood M. Shokrieh et al. [1] worked on four-leaf steel spring used in the rear suspension system of light vehicles is analyzed 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. The objective was to obtain a spring with minimum weight that is capable of carrying given static external forces without failure. The design constraints were stresses (Tsai–Wu failure criterion)

and displacements. The results showed that an optimum spring width decreases hyperbolically and the thickness increases linearly from the spring eyes towards the axle seat. 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.

B.Vijaya Lakshmi et al. [2] has presented the static analysis on 8-leafs. From the results she concluded that E-glass epoxy is better than using Mild-steel as though stresses are little bit higher than mild steel, E-glass epoxy is having good yield strength value ($5e+008\text{N/m}^2$) and also epoxy material components are easy to manufacture and this having very low weight as compared to other composite material.

Y. N. V. Santhosh Kumar et al. [3] carried out the research on Design and Analysis of Composite Leaf Spring for TATA SUMO. He deals with the replacement of conventional steel leaf spring with a Mono Composite leaf spring using E-Glass/Epoxy. In this the design parameters were selected and analyzed with the objective of minimizing weight of the composite leaf spring as compared to the steel leaf spring. In this leaf spring was modeled in Pro/E and the analysis was done using ANSYS software.

Kale Dipak, et.al.[4] had work on reducing the weight or mass of vehicles through a composite made leaf spring & increasing the strength of their leaf spring is focused. As vehicle leaf spring have contribution towards the amount of a weight to the automobile or vehicle and to reduce it to a single composite E-glass & Epoxy resin leaf spring is developed and an analysis using finite element method & experimental work is carried out. And it is prove that the final composite made leaf spring design stresses and FEA stresses are far less than the strength parameters or properties of a material satisfying the high stress failure criterion. It is achieved a permissible fatigue life of 221.16×10^3 cycles. This design for leaf spring made by composite is carried out for specifically for TATA sumo Grande version. Its model is fabricated using the hand lay-up manufacturing method and its experimentation is done. These designs carry for only the static loading condition and found safe for application.

Sorathiya Mehul et al.[5] has described static analysis of steel leaf spring and laminated composite Multi leaf spring. The objective of the paper is to compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. The dimensions of an existing conventional steel leaf spring of a Light design calculations. Static Analysis of 3-D model of conventional leaf spring is performed using ANSYS 11.0 and hyper mesh. Same dimensions are used in composite multi leaf spring using carbon/Epoxy and Graphite/Epoxy unidirectional laminates. The load carrying capacity, and weight of composite leaf spring are compared with that of steel leaf spring. The design constraints are stresses and deflection. After getting result he concluded that weight reduction of 79.617 % is achieved by using composite leaf spring. And if consider Mono leaf spring then Weight reduction is achieved 90.09%.

Pankaj Saini et al. [6] have compared the stresses and weight saving of composite leaf spring with that of steel leaf spring. The design constraint is stiffness. The material selected was 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 objective of minimizing weight of the composite leaf spring as compared to the steel leaf spring. The leaf spring was modeled in Auto-CAD 2012 and the analysis was done using ANSYS 9.0 software. After getting the result, he concluded that E-glass/epoxy composite leaf spring can be suggested for replacing the steel leaf spring from stress and stiffness point of view than the other composite material.

H.A. Al-Qureshi et al. [7] has worked on single leaf spring with variable thickness of glassfiber reinforced plastic (GFRP) with similar mechanical and geometrical properties to the multileaf steel spring was designed, fabricated and tested. Glassfiber reinforced plastic (GFRP) presents advantages over graphite/epoxy such as lower

sensitivity to cracks, impact and wear damage. The leaf spring model was considered to be a parabolically tapered, constant width beam carrying a concentrated load and assumed to be symmetrical with different cord lengths for the two limbs of the spring.

A finite element program is used to model the behavior of leaf spring. In addition analytical analysis can be used to develop an expression which is a function of thickness and position along the spring. In present work the hand lay-up vacuum bag process was initially employed and mandrels (male and female) were made from plywood according to the desired profile and the glass fiber fabric was cut to the desired lengths, so that when deposited on the mandrel, would give the calculated thickness. The operation was simply performed by depositing impregnated glass fiber with epoxy resin over the rotating mandrel in a hoop pattern. The spring was subjected to a series of laboratory static loading tests. This study demonstrated that composite can be used for leaf spring for light trucks (jeeps) and meet the requirement, together with substantial weight saving

M.Venkatesan, D.Helmen Devaraj [8] The objective of the paper is compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. The design constraints are stresses and deflections. The dimensions of an existing conventional steel leaf spring of a light commercial vehicle are taken. Same dimensions of conventional leaf spring are used to fabricate a composite multi leaf spring using E-Glass/Epoxy unidirectional laminates. Static analysis of 2- D model of conventional leaf spring is also performed using ANSYS 10 and compared with experimental results. Finite element analysis with full load on 3-D model of composite multi leaf spring is done using ANSYS 10 and the analytical results are compared with experimental results. Compared to steel spring, the composite leaf spring is found to have 67.35% lesser stress, 64.95% higher stiffness and 126.98% higher natural frequency than that of existing steel leaf spring. A weight reduction of 76.4% is achieved by using optimized composite leaf spring.

Shantanu Pawar et al.[9], carried out research to reduce the weight of the leaf spring using alternative material for the leaf spring for the application. It will include studying leaf with different composite materials .It is conclude that the Carbon-Glass-Carbon Epoxy Mono Composite Leaf spring shows 91.55 % efficiency analytically to FEA results and

83.04 % efficiency testing results to FEA results. That means it might be allowable for replacement for Steel leaf spring because efficiency is below 20 %.

V. Pandurangadu et al. [10] they worked on the design and analysis of laminated composite mono leaf spring. The dimensions of mono steel leaf spring of a passenger vehicle is taken for modeling and analysis of a laminated composite mono leaf spring with three different composite materials name subjected to the same load as that of a steel spring. The design constraints were stresses and deflections. The three different composite mono leaf springs have been modeled by considering uniform cross-section, with unidirectional fiber orientation angle for each lamina of a laminate. Static analysis of a 3-D model has been performed using ANSYS 10.0.They compared with the steel spring. He got the better results for composite material over conventional leaf spring.

N.Anu Radha, et al. [11] evaluated existing steel, carbon fiber and boron fibers and optimized the best one in concern with their performance. The boron fiber composite material can be replaceable with existing steel for master leaf spring. The master leaf spring is modeled in Pro/E (Wild Fire) 5.0 and analysis is carried out by using ANSYS 13.0 for better understanding. The objective of their work is to present modeling, stress analysis and material optimization of master leaf spring and comparison of deformation and stress results between steel leaf spring and composite leaf springs under same conditions. So for that the 3D-modelling has done in pro-E and analysis has done in ANSYS. Also comparative study has been done between composites like carbon fibre, boron fibre and conventional steel with respect to weight and strength. From the observations and results, they concluded that leaf spring with composite is lighter and economical than the conventional steel springs with same design specification

Ghodake A. P et al. [12] had done analysis of spring with constant width and thickness which was fabricated by hand lay-up technique and which was very simple and economical. The numerical analysis is carried via finite element analysis using ANSYS software. Stresses, deflection and strain energy results for both steel and composite leaf spring material were obtained. Finally he got the conclusion that the composite spring has maximum strain energy than steel leaf spring and weight of composite spring was nearly reduced up to 85% compared with steel material.

D.N. Dubey et.al.[13] worked on a mono parabolic leaf spring of a Maruti Omni Car. This paper describes design and experimental analysis of a conventional parabolic leaf and suggested composite material leaf spring .The composites used are HM and HS Carbon polymers .Finite Element analysis(FEA) is carried out at static condition of the spring model so that stress distribution can be observed for analysis of high stress zones. CAD model is prepared in Pro-E .The analysis has been observed for various loading conditions and the overall stress distribution zones have been studied. The objective is to compare the load carrying capacity ,stiffness and weight savings of composite parabolic leaf spring with that of a conventional steel leaf spring .The design constraints are stresses and deflections induced during various loading conditions. A comparative study has been made between carbon composite leaf spring and steel leaf spring with respect to weight and strength. The original steel leaf spring would weigh about 3.5 kgs whereas composite leaf spring would weigh 0.7314 kgs. So, we have observed that almost 65-70% of weight reduction could be achieved by using the carbon composites. At various loading conditions the composites under study show deflection as compared to conventional steel. The study has demonstrated that composite leaf springs would offer substantial weight savings.

IV. CONCLUSION

The current leaf spring is multiple leaf spring type with a steel material. It has high weight, low natural frequency, high corrosion, more noise and the property of material is changing when the load is acting, therefore current multiple leaf spring needs to be changed. The introduction of composite materials was made it possible to reduce the weight of leaf spring without any reduction on load carrying capacity and stiffness. The comparison of properties of steel material and composite material shows that replacement of steel leaf spring with composite material can be done. Composite material offers significant advantages as like more strength, less weight and hence more strength to weight ratio, more natural frequency, etc. The composite material offer opportunities for substantial weight saving. The weight of the leaf spring is reduced considerably by replacing steel leaf spring with composite leaf spring.

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