Abhishek Chandra, 2021, 9:1
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

Review of Leaf Spring Using Design Optimization

M.Tech. Scholar Abhishek Chandra, Prof. G.R. Kesheorey (Supervisor & HOD),
Dr. A.J. Siddiqui(Executive Director)
Department of ME
VITS, Indore
abhishekchandra56@gmail.com, grkvitsin@gmail.com

Abstract- The leaf spring is one of the vital components of heavy motor vehicle which absorbs shocks and vibration caused by uneven road surface. The leaf spring should possess high strength to withstand heavy loads and vibrations. The current research reviews various studies conducted in improving existing design of leaf spring using experimental and numerical methods. The use of composite materials as investigated by various researches is also studied.

Keywords:- FEA, mono leaf spring, ANSYS.

I. INTRODUCTION

Semi- elliptic leaf springs are almost universally used for suspension in light and heavy commercial vehicles. For cars also, these are widely used in rear suspension. The spring consists of a number of leaves called blades.

The blades are varying in length. The blades are usually given an initial curvature or cambered so that they will tend to straighten under the load. The leaf spring is based upon the theory of a beam of uniform strength. The lengthiest blade has eyes on its ends. All the bladesare bound together by means of steel straps.

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.

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 sprin 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 misses stress. d) If the eye distance is increased there is an increase in the average amount on von misses 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 Eglass/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 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.Al-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.

Erol Sancatkar, Mathieu Gratton [10] they have discussed about manufacturing of a composite leaf spring for a light vehicle run on solar energy. This paper have objective to give brief information regarding designing, numerically analysis and physical testing for future use of composite material for leaf spring.

They have suggested using unidirectional E-glass impregnated by an epoxy resin. Light vehicles running on solar power were selected for study. They have concluded after experimentations that small modifications can be employed such as placement rubber pads to enhance suspension capability of light vehicles. Their redesigns for front suspension of leaf springs for solar powered light vehicles were successful and meet all design requirements.

H.A. AL-QURESHI [11] they have studied automobile leaf springs and designed it with composite materials. The aim of this paper is to design, analysis and experimental investigations of composite leaf spring. For this aim they have selected a spring of compact car i.e. Jeep. For physical testing a single leaf spring with varying thickness of spring have been selected which having glassfiber reinforced plastic material with similar mechanical geometrical properties. That leaf spring was designed, fabricated & tested compared with multileaf spring. These experiments were done in laboratory and have been performed road test. For these testing's leaf spring material was replaced with GFRP. They have concluded that, GFRP leaf springs have more flexibility, hardness and stresses, noise parameters were get reduced than conventional steel leaf spring. Also Natural frequency and weight was reduced up to 80%.

I. Rajendran, S. Vijayarangan [12] they had applied artificial genetic algorithms for design optimization of composite leaf spring. Hence it was helped to reduce weight of leaf spring along with good strength and stiffness property. They have taken thickness and width as design variables for design optimization. They have suggested that, for optimization of leaf spring mathematical programming can be good instead of using many conventional and global methods. By using this technique reduction in weight of steel leaf spring was achieved up to 23.4%. For this, they have replaced mono leaf spring by seven leaf springs under identical conditions.

Mahmood M. Shokrieh, Davood Rezaei [13] In their work, they have selected four steel leaf springs used in rear suspension system of both light and heavy vehicles. For analysis they have used ANSYS V 5.4 software. Their main purpose is to minimize the weight and which will sustain external force without failure. For manufacturing of leaf spring they have opted fiberglass with epoxy resin material. By comparison they have found that, weight of composite leaf spring without eye end units reduced about 80% than steel leaf springs. Along with that, natural frequency was higher than steel leaf spring. They have shown different joints design for attaching of eye ends to opposite leaf spring with vehicle body.

Gulur Siddaramanna Shiva Shankar, Sambagam Vijayarangan [14] Due to increase in interest of replacing steel material of leaf spring with composites and reducing weight of vehicle Author has explained the procedure of design, analysis using ANSYS and manufacturing of mono composite leaf spring by using adhesive bonded end joints instead bolted joints. This was because of reducing stress concentration and delamination.

They have concluded that scarf type of bonded joint will increase strength of spring in comparison with lap type bonded joint. Their work includes mono leaf spring manufactured with variable thickness with constant cross sectional area of unidirectional glass fibre reinforced plastic with similar mechanical and geometrical properties to multileaf spring. For design of constant cross section of leaf spring they have used computer algorithm using C-Language. They have concluded that thickness of spring increases and width of leaf spring decreases hyperbolically from spring eye towards the axle seat.

They have given comparison results of load, deflection and stresses of steel for E-glass/Epoxy, Graphite/Epoxy, Carbon Epoxy material leaf springs. They have found after experimentation that, E-Glass/Epoxy leaf spring performance was good in between them. They have done harmonic analysis

and found that. Natural frequency of composite leaf spring was higher than that of steel leaf spring. After last they have noticed that, chipping resistance was one of disadvantage with using composite leaf spring. In that, Matrix material of composites was likely to chip off when subject to poor road environment's which may start break out some fibers in lower part spring.

Mouleeswaran Senthil Kumar, Sabapathy Vijayarangan [15] in this Paper, author have made experimental and analytical investigation was made for fatigue life prediction of steel and composite multi leaf spring by using data analysis. Composites are those material made up of glass fibre reinforced polymer. Static analysis was done by considering dimensions of existing conventional leaf spring using ANSYS 7.1 and that software results are compared with experimental results.

They have taken parameters like load carrying capacity, stiffness, and weight of leaf spring for experimental investigation.

After their work they have predicted that, composite leaf spring having 67.35% lesser stress, 64.95% higher stiffness, 126.98% higher natural frequency and weight was reduced by 68.15% in comparison with steel leaf spring. Hence author has concluded that, fatigue life of composite leaf spring was more than that of conventional steel leaf springs.

III. CONCLUSION

The leaf spring should possess high strength to With stand heavy loads and vibrations. The current research reviews various studies conducted in improving existing design of leaf spring using experimental and numerical methods. The use of composite materials as investigated by various researches is also studied.

REFERENCES

[1] Mahmood M. Shokrieh, Davood Rezaei " Analysis and optimization of a composite leaf spring " Composite Structures, 60 (2003) 317–325.

[2] E. Mahdi a, O.M.S. Alkoles a, A.M.S. Hamouda b, B.B. Sahari b, R. Yonus c, G. Goudah " Light composite elliptic springs for vehicle suspension " Composite Structures, 75 (2006) 24–28.

[3] Y. N. V. Santhosh Kumar, M. Vimal Teja "Design and Analysis of Composite Leaf Spring" Dept. of Mechanical Engineering, Nimra College of Engineering & Technology, Ibrahimpatnam, Vijayawada. (2012)

[4] Pankaj Saini, Ashish Goel, Dushyant Kumar "Design and analysis of composite leaf spring for light vehicles" International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 5, May 2013.

[5] Manas Patnaik, Narendra Yadav, Ritesh Dewangan "Study of a Parabolic Leaf Spring by Finite Element Method & Design of Experiments" International Journal of Modern Engineering Research Vol.2, Issue 4, July-Aug 2012 pp-1920-1922.

[6] Malaga. Anil Kumar, T.N.Charyulu, Ch.Ramesh "Design Optimization Of Leaf Spring" International Journal of Engineering Research and Applications Vol. 2, Issue 6, November-December 2012, pp.759-765.

[7] Prahalad Sawant Badkar, Prahalad Sawant Badkar "Design Improvements of Leaf Spring of BEML Tatra 815 VVNC 8 X 8 Truck" International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 1, January 2013.

[8] H.A.Al-Qureshi "automobile leaf spring from composite materials" Journal of materials processing technology, 118(2001).

[9] Ashish V. Amrute, Edward Nikhil karlus, R. K. Rathore "design and assessment of multi leaf spring'' International journal of research in aeronautical and mechanical engineering, ISSN: 2321-3051. November (2013).

[10] Erol Sancaktar, Mathieu Gratton, "Design, Analysis, And Optimization Of Composite Leaf Springs For Light Vehicle Applications" ELSEVIER-Composite strucures (1999) 195-204.

[11] H. A. Qureshi, "Automobile leaf spring from composite material" ELSEVIER-Journal of material processing technology 118 (2001) 58-61.

[12] Rajendran, I., Vijayarangan, S. "Optimal Design of a Composite Leaf Spring using Genetic Algorithms", ELSEVIER-International Journal of Computer and Structures 79 2001: 1121 –1129.

[13] Mahmood M. Shokrieh, Davood Rezaei, "Analysis and optimization of a composite leaf spring" ELSEVIER-Composite Structures 60 (2003) 317–325.

[14] Gulur Siddaramanna Shiva Shankar, Sambagam "Mono Composite Leaf Spring For Light Weight Vehicle– Design, End Joint Analysis And Testing"

ISSN 1392–1320 Materials Science (Medžiagotyra). Vol. 12, No. 3. 2006.

[15] Mouleeswaran SENTHIL KUMAR, Sabapathy VIJAYARANGAN, "Analytical and Experimental studies on Fatigue Life Prediction of steel and composite Multileaf spring for Light Passenger Vehicles using Life Data Analysis" Materials science . vol. 13. No. 2. 2007.