OPTIMIZATION OF MULTILEAF SPRING USING COMPOSITE MATERIAL:A Review

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Abstract: In order to conserve natural resources and economize energy, weight reduction has main focus of automobile manufacturer in present scenario.The weight reduction can be achieved with the help of introduction of better material design optimization & better manufacturing process.In automobile sector suspension system is one of the area under which weight reduction is possible by introducing better material, because it accounts for 10 to 20% of upsprungweight.It is well known that, spring are design to absorb and store energy & then release it. Hence strain energy of the material becomes major factor in designing the spring. The introduction of composite material was made it possible to reduce the weight of leaf spring without any load carrying capacity and stiffness ,since the composite material have maximum elastic strain energy storage capacity & high strength to weight ratio as compared to there of steel.

Keywords:Multi-leafspring;simulation;fatigue,stressanalysis;weight reduction

1.Introduction

Leaf spring in an automobile provides a good suspension and plays a vital role in carrying loads and absorbing vibrations. The leaf spring is one of the potential items for weight reduction in automobile as it accounts for ten to twenty percent of the upsprung weight. Mainly leaf springs are made of isotropic steel. The automobile industry has shown great interest in replacement of steel parts with composite materials. Owing to high strength and stiffness to weight ratios the requirement of computer aided analysis arises because of anisotropy of composites which makes calculations quite intensive and large number of variables on which the mechanical properties of composite depends. For example fiber material, matrix material, fiberorientation in a ply, layup of a laminate etc. In the present work stress and deflection analysis ofleaf spring are calculated by finite element analysis. The leaves of the spring are assigned properties of steel or fiber reinforced composites. The leaf springs are analyzed in ANSYS 16.0 for stresses and deflections. The results indicate that for the same load carrying capacity there is lowering of induced stresses and deflections when steel leaves are replaced by fibrous composite leaves.

2.Literature Review:

Before starting any dissertation work, the literature review of the topic is must, because it helps us in knowing the amount of work that has been done in that topic by the different researchers. It also helps us in doing the further work by taking the reference of the previous work done in the best possible way.

Pankaj Saini, Ashish Goel and Dushyant Kumar. In this paper, they consider passenger vehicle with ten-

leaf steel spring for analysis of stress and deflection . The objective is to compare the stresses and weight savings of composite leaf spring with that of steel leaf spring. The material selected was E-glass/epoxy, carbon epoxy and graphite epoxy which is use against conventional steel. The dimensions and the number of leaves for both steel leaf spring and composite leaf springs are considered to be the same. [1].

Mahmood M. Shokrieh and DavoodRezaei have worked on analysis and optimization of a composite leaf spring**.** In this work, they consider light vehicle rear suspension system with four-steel leaf spring for analysis of stress and deflection .They concluded that the optimize composite leaf spring has much lower stress as compared to steel spring and the spring weight without eye units which having in steel is 9.2 kg is decrease by 80 % of its value. The natural frequency of composite leaf spring is higher than that of the steel leaf spring[2].

M.Venkatesan and D.Helmen have worked on design and analysis of composite leaf spring in light vehicle. In this paper, they consider passenger cars with seven-leaf steel spring for analysis of stress and deflection. The objective is to compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. They concluded that, the composite leaf spring having 67.35% less stress, 64.95% higher stiffness and 126.98% higher natural frequency than that of existing steel leaf spring. [3].

GulurSiddaramanna Shiva Shankar and SambagamVijayarangan have worked on mono composite leaf spring for light weight vehicle – Design, end joint analysis and testing. In this paper, they consider light weight vehicle leaf spring for analysis of stress and deflection by using ANSYS software. The design constraints were stresses and deflection for both materials. They concluded that optimize composite spring having much lower stress, weight is reduce nearly 85 % and the natural frequency is higher as compared to steel leaf spring[4].

Mouleeswaran Senthil Kumar and SabapathyVijayarangan have done work on analytical and experimental studies on fatigue life prediction of steel and composite multi-leaf spring for light passenger vehicles using life data analysis. The objective iscompre the load carrying capacity, stiffness, and fatigue life and weight savings of composite leaf spring with that of steel leaf spring. They analyze that, the composite leaf spring has 67.35 % lesser stress, 64.95 % higher stiffnessand126.98 % higher natural frequency compare to existing steel leaf spring. A weight reduction of 68.15 % is also achieved by using composite leaf spring. Also they concluded that, the composite leaf spring fatigue life is more than that of conventional steel leaf spring [5].

K. K. Jadhao and DR. R. S. Dalu have worked on experimental investigation & numerical analysis of composite leaf spring. Primary objective is to compare the load .They concluded that, Composite leaf spring have much lower stress and higher stiffness than that of existing steel leaf spring. Also they concluded that weight of composite leaf spring was nearly reduced up to 85% compare to steel leaf spring[6].

Kumar Krisha and Aggarwal M.L have worked on Computer aided FEA comparison of mono steel and mono GRP 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. They consider design constraints were stresses anddeflections.

From the results they concluded that,

When steel leaf spring is replaced by composite material (GRP), the deflection is reduced by6.51%.

The material saving 71.85% is obtained by weight[7].

Joo-teck Jeffrey and TarlochanFaris have worked on Finite element analysis on the static and fatigue

characteristics of composite multi-leaf spring. They concluded that, the maximum bending stresses and deflection in composite leaf spring are much lower than that of steel spring. The fatigue life of E-glass/epoxy or E- glass/vinyl ester composite leaf spring was proven to be 2 and 4 times higher than that of steel leaf spring[8].

N. P. Dhoshi, Prof. N. K. Ingole and Prof. U. D. Gulhanehave worked on analysis and modification of composite leaf spring of tractor trailer using analytical and finite element method. In this paper, they consider tractor trailer with seventeen-leaf steel spring for analysis of stress and deflection. They concluded that, the composite leaf spring have much lower stress and deflection than that of existing steel leaf spring. Also they concluded that weight of composite leaf spring was nearly reduced up to 80% compare to steel leaf spring [9].

M. M. Patunkar and D. R. Dolas have worked on modelling and analysis of composite leaf spring under the static load condition by using FEA. In this paper, they consider commercial
vehicle suspension system with leaf spring for modeling and analysis of stress, deflection and weight reduction ratio. They concluded that optimize conventional steel leaf spring have weight 23 Kg. whereas composite leaf spring weight is only 3.59 Kg. So it is indicating the reduction in weight by 84.40% at same level of performance. Composite leaf spring can be used on smooth road with very high performance expectations. However on rough road conditions due to lower chipping resistance failure from chipping of composite leaf spring[10].

M Senthil Kumar and S Vijayarangan have worked on static analysis and fatigue life prediction of steel and composite leaf spring for light passenger vehicles. They describe static and fatigue analysis of steel leaf spring and composite multi leaf spring. Primary objective is to compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. They have compared the analysis results with experimental results. They concluded that, Composite leaf spring have 67.35% lesser stress, 64.95% higher stiffness and 126.98% higher natural frequency than that of existing steel leaf spring.[11].

H.A. Al-Qureshi has worked on automobile leaf springs from composite materials. The aim of this paper is to present a general study on the analysis, design and fabrication of composite springs. From this viewpoint, the suspension spring of a compact car, ``a jeep'' was selected as a prototype. He concluded that, composite leaf spring have better fatigue behavior than steel spring. Also he found the hybridization technique can be used effectively to improve weight saving and performance in the automotive industry[12].

J.P. Hou, J.Y. Cherruault, I. Nairne, G. Jeronimidis and R.M. Mayer have worked on Evolution of the eye -end design of a composite leaf spring for heavy axle loads. In this paper, they consider freight rail applications with two leaf steel spring for analysis of stress and deflection. They concluded that, composite leaf spring have lesser stress, higher stiffness compared to steel leaf spring. Also they concluded that, composite leaf spring have very good fatigue life than that of existing steel leaf spring and reduction of shear stresses in eye-end design [13].

Vinkel Arora, Dr. M. L. Aggarwal have worked on a comparative study of CAE and experimental results of leaf springs in automotive vehicles. In this paper, they consider commercial vehicle suspension system with front end leaf spring for modeling. This conventional leaf spring model consists of 37 parts.. From the results obtained from ANSYS, they concluded that the leaf spring is fully/half loaded, a variation of 1.17% in deflection is observed among the experimental & CAE value, which proves the validation of our CAD model and analysis. [14].

Mr. Anandkumar A. Satputeworked on mono composite leaf spring – design and testing. In this work, they consider light vehicle of Maruti Omni's rear suspension system. The objective is to compare strength and weight savings of composite leaf spring with that of steel leaf spring. After they concluded that the results of the analytical and experimental analysis are almost same and they use the composite material instead of steel, they have to change dimensions. Here they havechanged.[15].

I. Rajendran and S. Vijayarangan had studied about optimal design of a composite leaf spring using genetic algorithms. In this paper, they consider automobile steel leaf spring for solution of fatigue failure and weight reduction ratio by using genetic algorithms.. Also from the result, they concluded that the composite leaf spring have very good fatigue life than that of existing steel leaf spring and weight reduction is achieved 75.6%[16].

Abdul Rahim Abu Talib, AidyAli, have worked on developing a composite based elliptic spring for automotive applications. They consider light and heavy trucks with steel elliptic spring for analysis of fatigue behavior. The objective is to compare the load carrying capacity, fatigue behavior and weight savings of composite leaf spring with that of steel leaf spring. They concluded that composite elliptical springs have better fatigue behavior than the conventional steel leaf spring and weight reduction ratio is achieved[17].

Malaga. Anilkumar, T. N. Charyulustudied on design optimization of leaf spring. The objective of this paper is to replace the multi-leaf steel spring by three types composite leaf spring for the same load carrying capacity and stiffness. From the static analysis results, they saw that the von-mises stress in the steel is 596.047 MPa and the von-mises stress in E-glass/epoxy, Graphite/epoxy and Carbon/epoxy is 475.606 MPa, 1556 MPa and 1061 MPa respectively. And they was found that the maximum displacement of 92.591 mm in the steel leaf spring andthecorrespondingdisplacementsinE-glass/epoxy,graphite/epoxy[18].

Makarand B. Shirke and Prof. V. D. Wakchaure studied on performance association of static and fatigue behavior of steel and glass epoxy composite leaf spring of light motor vehicle. They consider light motor vehicle steel leaf spring The objective is to reduce cost, weight that is capable of carrying given static external forces without failure. From the analysis they concluded that, the composite leaf spring have62.27 % lesser stress and lesser deflection compared to steel leaf spring. The predicted fatigue life of the steel leaf spring is 10^6 cycles and composite leaf spring is 10^9 cycles [19].

Abdullah*et al*. (2009) analyzed and evaluated the capability of parabolic spring to replace the multi leaf in suspension system. Finite element analysis had been performed to analyze the stress distribution and behavior for both type of springs. Multi leaf can hold much more load then parabolic spring, but in terms of material usage and space requirement, parabolic spring has the advantages. For multi-leaf, the stress was concentrated at the center part, while for parabolic, stress was distributed well at the both side of the part.[20]

Ajay B.K., MandarGophane studied on Design and Analysis of Leaf Spring with Different Arrangements of Composite Leaves with Steel Leaves." It is observed that the composite material arrangement shows more deflection and stress than that of steel material leaf spring but the model 4 gives considerable reduction in weight and whose FOS is also 4.1 close to steel leaf springs FOS of 4.5.[21]

Shambabunutalapati studied on design and analysis of leaf spring by using composite material for light vehicles. He studied the model of "Mahindra ommandar-650Di" and concluded that "Composite monoleaf reduces the weight by nearly 84% for e-glass / epoxy. From fatigue analysis result ,the usage of factor of e-glass/epoxy is very much

less compared to steel.Hence it is advantages to replaces steel leaf spring with e-glass/epoxy."[22]

FARIS *et al.* (2012) investigated the static and fatigue behaviors of steel and composite multileafspring . The same dimensions were used to design composite multi-leaf spring or the two materials-glass fiber/epoxy and E-glass fiber/vinyl ester, which are of great interest to the transportation industry. Compared to the steel leaf spring, the designed composite spring has much lower bending stresses and deflections and higher fatigue life cycles[23].

Manjunath H.N, Manjunath.K, T.Rangaswamystudied on Static Analysis and Fatigue Life prediction of Composite Leaf Spring for a Light Commercial Vehicle (TATA ACE) and conclude that "A comparative study has been made between different composite materials and with steel in respect of stiffness, deflection and stress. Hence composite leaf spring has good performance characteristics as compared to conventional steel spring with similar design specifications."[24]

3.Design Methodology:

1. Modeling of mutli-leaf spring was done in academic version of SOLIDWORKS
2. Geometric Model of the multi leaf spring is imported in academic version of ANSYS 16.0.
3. Finite element analysis of multi leaf spring has been done using three different materials (steel, carbon/epoxy and glass/epoxy).
4. Stresses and deflections are obtained from finite element analysis for three different materials are compared and conclusions drawn.

4.Conclusion :

A comparative study has been made between composite leaf spring and steel leaf spring with respect to stress and deflection. By employing a composite leaf spring for the same load carrying capacity, there is reduction in stresses,reduction in deflection and reduction in weight which results in more fuel efficiency and improved riding qualities. So composite is a good replacement for steel for multileaf springs.

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