International Journal of Engineering Research
Volume No.4, Issue No.12, pp : 685-688
ISSN:2319-6890 (online),2347-5013(print)
1 Dec. 2015

Performance Analysis Of Composite Material Multileaf Spring : Critical Review

Ranjeet S. Mohod[1], Dhiraj P. Kapoor[2]
[1]AP, Government College of Engineering Amaravati, Maharashtra, India
[2]AP, Government College of Engineering , Chandrapur, Maharashtra, India

Abstract - The review paper aims at focusing the prominent and pioneering work addressing the design and analysis of multi-leaf spring. Rigidity and load carrying capacity are the prime concern in selection of material for suspension component which indirectly emphasize upon the passenger comfort. Exploring and using composite as material for leaf spring, instead of conventional steel materials has gathered attention of researchers and automotive manufacturers due to potential characteristics of composites. But its feasibility and reliability needs to be dogged out and addressed to the greater extent. The paper attempts to brief out the attempts made hitherto.

Keywords : *multi-leaf spring, carbon fiber reinforced polymers, glass fiber reinforced polymers,*

Introduction

Now days the horse-drawn carriage having flexible leaf springs fixed at four corners to latest automobile techniques using complex control algorithm, the suspension systems are widely used. Isolate the vehicle body from road irregularities and to maintain contact of the wheels with the roadway these are the two main aspects which are mainly considered while designing the suspension of road vehicle. With the use of springs and dampers and by rubber mountings at the connections of the individual suspension components, isolation can be achieved. Road disturbance and load disturbance these are two categories of disturbances on vehicle, which are to be considered while designing the suspension system. Variations of loads due to accelerating, braking and cornering are included in load disturbances. Large magnitude in low frequency e.g. hills and small magnitude in high frequency like road roughness is the characteristics of road disturbances. A good suspension design, therefore, is concerned with disturbance rejection from these disturbances to the outputs. The elastic resistance requirement of suspension system to absorb the road shocks is achieved by suspension springs.

The light weight engineering becomes more and more import. Demand of efficient or high performance products are the need of today because of rising energy cost and the international growing request to save the environment with the help of optimized usage of resources and the reduction of emissions. The use of fiber reinforced polymers is perhaps the most promising technology in this field. Such materials like carbon fiber reinforced polymers (CFRP) or glass fiber reinforced polymers (GFRP) are used in many different branches for example the aerospace industry, the energy industry or the transportation industry. With the help of new material, change in design parameters and modern manufacturing processes it is possible to achieve greater life of leaf spring.

Literature Survey and Review Report

A number of research papers have been published on the static and dynamic analysis of leaf springs. A brief review of some selected references on this topic is represented.

Ashish Borhade et.al. [1] , Mahanth kumar et.al. [2] in discussed the analysis of Steel Leaf spring. .In this work Modal Analysis is carried out using ANSYS Software and results are compared with experimental (FFT Analyzer) results and theoretical results. Experimental modal analysis and FEA analysis results has been validated .

Venu et.al. [3] in their research paper discussed Static and Modal Analysis of Leaf Spring with Eyes Using FEA Packages. In analysis part the finite element of leaf spring is modeled using solid tetrahedron10-NODE-187 elements. Along with that they have done the Berlin type of leaf spring eyes analysis by using ANSYS 11. By performing dynamic analysis it is concluded that the stresses in the eyes of composite leaf spring are much lower than that of the eyes of steel spring, for composite leaf spring eye the strength to weight ratio is higher than conventional steel leaf spring eye with similar design.

Ritesh Mistry et.al. [4] in discussed dynamic analysis of leaf spring. Four leaves spring used in suspension of a light vehicle is considered and analyzed by Ansys 14. Finite element analysis results has been validated with analytical results . Dynamic load Analysis ha also been carried out in Ansys 14 .Material of the leaf is Steel EN45A. Based on the turning direction ,the load coming on to the leaf spring has been estimated as a function of time.

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R. M. Borhania et.al. [5] in their research paper discussed the Static and Dynamic Analysis of Automobile Leaf Spring (TATA ACE). Composites material carbon/Epoxy and Graphite/Epoxy has been studied for static conditions and dynamic analysis has also been addressed for a time step of 5 second .Composites have shown good strength to weight ratio and modal analysis carried out to extract modal parameters

B. Mahesh Babuet.al. [6] in their research paper discussed The Leaf Spring Analysis with Eyes Using FEA. This paper discussed about estimation of the deflection, stress and mode frequency induced in the leaf spring. The analyzed leaf spring is a custom designed leaf spring with different eyes viz. Berlin and upturned eyes with different materials at different section. The main focus of project is comparative study of design parameters of a traditional steel leaf spring assembly and bonded and ends joint composite leaf spring. The dynamic analysis is performed using ANSYS WORK BENCH software. The excitation frequency are compared with the natural frequencies of various parametric combinations for different road irregularities. The excitation frequencies are determined by mathematical calculations. It is observed from the work that the values of natural frequencies and excitation frequencies are the same for both the springs as the geometric parameters of the spring are almost same except for number of leave

B. vijaya Lakshmi et.al. [7] discussed in their research paper about the static and dynamic analysis of composite leaf spring in heavy vehicle. The objective of this paper was to compare, stiffness, load carrying capacity and weight savings of composite leaf spring with steel leaf spring. The dimensions of an existing conventional steel leaf spring of a Heavy commercial vehicle are taken and, same dimensions of conventional leaf spring are used to fabricate a composite multi leaf spring using E-GLASS/EPOXY, C-GLASS/EPOXY, S-GLASS/EPOXY material. For modeling Pro-Engineer software is used and COSMOS is used for analysis. Static & Dynamic analysis of Leaf spring is performed by using COSMOS. They analyzed two leaf springs i.e. 8 leaf and 12 leaf springs. 8 leaf spring gives better results for S –glass epoxy while 12 leaf spring for E-glass Epoxy. The conclusion was S-glass epoxy is the best material to manufacture leaf spring because of good structural stability low production cost and good efficiency.

K. A. Sai Anuraag et.al. [8] in their research paper discussed The Comparison of Static, Dynamic & Shock Analysis for Two & Five Layered Composite Leaf Spring. The leaf springs are modeled with Unigraphics software NX7.5 and the analysis is carried out using ANSYS 11.0 FEA software to predict the behavior. In the structural analysis Solid46 is taken as the element type. They selected two springs for analysis i.e. two leaf and five leaf springs. From this work they concluded that, in static analysis the maximum displacement is observed in two layered and, more Von-mises stress in five layered spring. In modal analysis, the range of frequencies for two layers is 19.2 Hz to 1433 Hz and for five layers is 21.2 Hz to 1612 Hz.

Putti Srinivasa Rao et.al. [9] Studied about the Modal and Harmonic Analysis of Leaf Spring Using Composite Materials in their research paper. In this work four composite materials I.e. E-glass/epoxy, graphite/epoxy, carbon/epoxy, Kevlar/epoxy are considered. For finding the natural frequencies for all the materials of the multi leaf spring for the first five modes the modal analysis was carried out theoretically. Modal analysis is conducted in ANSYS software for the first five modes to validate the theoretical modal analysis. Creo3.0 was used for modeling and ANSYS 12.1 was used for analysis. In the modal analysis it is observed that natural frequencies are higher for Kevlar/ epoxy than steel and other composite materials. From harmonic analysis it is observed that E-glass/epoxy and carbon/epoxy have high amplitude of response than other materials and Kevlar/epoxy, graphite/epoxy and steel have low amplitude of response.

Tejas rathi et.al. [10] in their research paper discussed about ,the Static, Dynamic and Fatigue Analysis of composite leaf spring for light weight vehicle. To compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring was the main objective. Solid Works 2011 was used for modeling of leaf spring. Analysis is done using ANSYS software. In this paper understanding of behavior of Composite Leaf Spring is attained taking every possible detail into account.

Vivek Rai et.al. [11] in their research paper discussed The Development of a Composite Leaf Spring for a Light Commercial Vehicle (Tata Magic). This includes the replacement of multi-leaf steel spring with mono composite leaf spring for the LCV. ANSYS software was used for modeling as well as for analysis of both the steel and composite leaf springs. The steel material used is EN47 and composite material is E-glass/epoxy. This work involved the comparison of steel leaf material EN 47 and Composite material leaf spring under static loading conditions. From the result obtained it has been concluded that the development of a composite mono leaf spring has very effective than steel leaf spring.

Kaushal P. Khalokar, et.al.[12] in their research paper discussed the design and analysis of composite leaf spring in light vehicle. Multi leaf springs having nine leaves used by a commercial vehicle was used to work on. This project

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described design and experimental analysis of composite leaf spring made of glass fibre reinforced polymer. The objective of this paper was to compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. The composites material used is E-Glass/Epoxy unidirectional laminates. Using ANSYS 14.5 finite element analysis with full load on 3-D model of composite multi leaf spring is done and the analytical results are compared with experimental results Compared to steel spring. It is seen that, the composite leaf spring have 64.95% higher stiffness, 67.35% lesser stress 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, hence the study demonstrated that composites can be used for leaf springs for light weight vehicles and meet the requirements, together with substantial weight savings.

Shabbir, et.al. [13] in their research paper discussed The Analysis of Composite Leaf Spring using FEA of Light Vehicle Mini Truck. In this study the attempt has been made to get the new material for leaf spring. In this study material selected was glass fiber reinforced plastic and the polyester resin. The numerical analysis is carried via finite element analysis using ANSYS software for two composite material leaf springs. Stresses, deflection and strain energy results for two different composite leaf spring materials were obtained. From the static analysis results it is found that there is a maximum equivalent stress is observed in Kevlar epoxy leaf spring. From modal analysis it is observed that Kevlar epoxy unidirectional composite material natural sustainable frequency is more than S-glass Epoxy unidirectional composite material.

Sushil B.Chopade et.al. [14], their research paper discussed the Design and Analysis of E-Glass/Epoxy Composite Mono leaf Spring for Light Vehicle. The weight of light vehicle is considered in this paper. Their work also aimed on the application of FEA concept to compare two materials for leaf spring and propose the one having higher strength to weight ratio . In the present work deflection and bending stresses induced in the two leaf springs are compared the solid modeling of leaf spring is done in CATIA V5 and analyzed using ANSYS 14.5.

Ashvini P. lad, et.al. [15] in their research paper discussed the deflection analysis of steel leaf spring vs composite leaf spring through FEA software. To present analysis of deflection of composite leaf spring (epoxy carbon fiber) to the conventional steel leaf spring through FEA software was the objective. In ANSYS , maximum deflection in horizontal and vertical direction are determined by giving up to 150 kg vertical load in steps of 50 kg rise, at centre of each leaf spring manufacturer of Maruti 800 car recommended the same. When compared with regular steel leaf analysis, the deflection is found satisfactory. Loading deflection - ANSYS results of steel leaf & epoxy carbon fiber leaf are compared and found similar with acceptable range of difference. i.e. 7 %.

Conclusion

The literature review discussed above depicts that the design of mechanical springs used in automobiles is quite necessary to do it's deign analysis which involves stress distribution analysis, maximum displacement and different mode of failure. Over the complete span of service life the springs undergo the fluctuating loading. In addition, For performing the stress analysis of mechanical springs various design softwares like ANSYS, Solid Works, Pro-E, CATIA, Autodesk Inventor, etc., have been widely used. In most of the above cases shear stress, fatigue stress, maximum displacement calculation play significant role in the design of mechanical springs. In calculating the number of active turns and mean diameter in helical compression springs shear stress and deflection equation is used is seen from above studies. Theoretical results obtained by the shear stress equation when compared with Finite Element Analysis (FEM) of springs provide the better solution of the problems arises in the existing design of the mechanical spring. The designers, in future, will get help for predicting the safe design of mechanical springs used in the automobiles for better and comfortable ride.

In this study general discussion on design, analysis of leaf spring is carried out for enhancement of the fatigue life. The main purpose of doing this work is to increase life of leaf spring i.e. reduction of the stresses at peak loading condition. For improve life of leaf spring and its durability modifications can be implemented by changing the material, changing the physical parameters like Span of the leaf spring, thickness of the leaf, width of the leaf ,number of leaves. This study will help to understand more the behavior of the spring by using CAE and give information for the manufacturer to improve the fatigue life of the spring by changing design parameter. Finite element analysis is carried out by changing design parameter with conventional spring and modified spring. The result will compare with experimental result.

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