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A Review on Automotive Car Composite Leaf Spring Design and Optimization

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***Abstract*— Nowadays growth in competition and innovation in automotive sector tends to modify the existing products or replace old and outdated products by newly innovated and advanced material products.A suspension system of any vehicle is also an area where these types of innovations are carried out consistantly.To increasing the comfort of user there are lots of efforts are taken.Basically leaf springs are mostly used as a suspension system in automotive vehicles.The leaf spring design optimization will be performed periodically by changing from conventional steel to composite material.generally the composite materials are mostly used in various areas such as marine,automobile,aerospace structure etc. Due to high strength they are widely used in the low weight applications and also as an alternate for metals to reduce the material cost.This paper presents literature review on, compatibility of composite material for leaf spring in automobile.Comparison with the conventional leaf spring. Also the design and analysis of composite leaf spring.**

***Keywords*— Ansys, carbon fiber material, composite material, F.E.A, Static analysis.**

I. INTRODUCTION

The leaf spring should absorb the vertical vibrations and impacts due to road irregularities by means of variations in the spring deflection so that the potential Energy is stored in spring as strain energy and then released slowly. So, increasing the energy storage capability of a leaf spring ensures a more compliant suspension system. According to the studies made a material with maximum strength and minimum modulus of elasticity in the longitudinal direction is the most suitable material for a leaf spring. Fortunately, composites have these characteristics. Fatigue failure is the predominant mode of in-service failure of many automobile components. This is due to the fact that the automobile components are subjected to variety of fatigue loads like shocks caused due to road irregularities traced by the road wheels, the sudden loads due to the wheel traveling over the bumps etc.

The leaf springs are more affected due to fatigue loads, as they are a part of the unstrung mass of the automobile. The fatigue behaviour of Glass Fiber Reinforced Plastic (GFRP) epoxy composite materials has been studied in the past. Theoretical equation for predicting fatigue life is formulated using fatigue modulus and its degrading rate. This relation is simplified by strain failure criterion for practical application. A prediction method for the fatigue strength of composite structures at an arbitrary combination of frequency, stress ratio and temperature has been presented. These studies are limited to mono-leaf springs only.

In the present work, a steel spring used in passenger cars is replaced with a composite leaf spring made of glass/epoxy composites. The dimensions for both steel leaf spring and composite leaf springs are considered to be the same. The primary objective is to compare their load carrying capacity, stiffness and weight savings of composite leaf spring. Finally, fatigue life of steel and composite leaf spring is also predicted using life data.

II. LITERATURE REVIEW

It has been classified into three different areas such as composite material for leaf spring, design and optimization of composite leaf spring and lastly analysis of composite leaf spring.

A) Material used for leaf spring-

By using composite material for leaf spring, there are so many characteristics which are,Good fatigue strength.High strength to weight ratio.High natural frequency.Good corrosion resistance.Then the application of composite material for leaf spring is to reduces the weight of leaf spring without reducing the stiffness and load carrying capacity in the suspension system.

Some composite materials which are proposed for leaf spring which are given below in the table as per year.

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Type of composite material	Researcher
S2-glass fiber/ Epoxy and E-glass/ Epoxy	W.J. Yu. Kim[1988]
E-glass fibre with two layer of bidirectional fabric	Erol Sancatar [1999]
E-glass/Epoxy and carbon fiber/Epoxy	H.A.Al. Qureshi[2001]
E-glass/Epoxy and Woven roving/ Epoxy	G Gular Siddaramanna et.al[2006]
Woven glass fiber Baric	E.Mahdi et.al [2006]; Abdul Rahim [2010]
20% glass fiber reinforced polypropylene	C.Subhramian ,et.al [2011]
Glass/Epoxy, Graphite/Epoxy, arbon/Epoxy	B.Ragu Kumar et.al [2013]
E-Glass/Epoxy, C-Glass/Epoxy, S-Glass /Epoxy	B.Vijaya Lakshmi1 I. Satyanarayana[2012]
Carbon/epoxy	Parkhe Ravindra ,Sanjay Belkar [2014]
C-glass/epoxy composite leaf spring	Mhaske Raman, Nimbalkar et.al [2014]

B) Design & Optimization of Composite Leaf Spring-

For the design of leaf spring the design constraints are stresses and deflections. Finite element analysis with full bump load on 3-D model of composite multi leaf spring is done using ANSYS 7.1 and the analytical results are compared with experimental results. Fatigue life of steel leaf spring and composite leaf is also predicted. 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 68.15 % is also achieved by using composite leaf spring. It is also concluded that fatigue life of composite is more than that of conventional steel leaf spring.(Senthilkumar M. and Vijayarangan S,2007).

The leaf spring geometry and deformations are modeled using nodal degrees of freedom defined with respect to the spring body coordinate system. By assuming that the leaf deformation can be large but the leaf deformed shape remains simple, component mode synthesis techniques can be used to significantly reduce the number of deformation coordinates. The nonlinear stiffness matrix is first developed for the finite element of each leaf and is used to determine the overall leaf spring stiffness matrix. The pre-stresses, the contact and friction that characterize the nonlinear behavior of leaf springs are discussed. Using the nonlinear leaf spring formulation presented in this study, a detailed multibody model for a sport utility vehicle is developed. It is shown that the proposed leaf spring model that accounts for the effect of windup, contact and friction between the spring leaves can be effectively used for assessing the dynamic stability of sports utility vehicles. (Hiroyuki Sugiyama, Omar M.A, et al.2006).

Study the Premature fracture in automobile leaf springs. In this work, the origin of premature fracture in leaf springs, used in Venezuelan buses, is studied. To this end, common failure analysis procedures, including examining the leaf spring history, visual inspection of fractured specimens, characterization of various properties and simulation tests on real components, were used. It is concluded that fracture occurred by a mechanism of mechanical fatigue, initiated at the region of the central hole, which suffered the highest tensile stress levels. Several factors (poor design, low quality material and defected fabrication) have combined to facilitate failure. Preventive measures to lengthen the service life of leaf springs are suggested. Premature failure in the studied leaf springs by fracture of a leaf was the result of mechanical fatigue caused by a combination of design, metallurgical and manufacturing deficiencies. (Fuentes J.J, Aguilar H.J, et al. 2009).

(Krishan Kumar, Aggarwal M.L,2017) Have optimize Various Design Parameters for EN45A Flat Leaf Spring. Leaf springs are widely used as suspension system in automotive vehicles. In the present work, optimization of design parameters of flat leaf springs have been carried out: keeping into account the effect of shot peening intensity, reduction in the weight of components and increase in fatigue life at wide range of operating conditions. A computer program using Visual Basics has been prepared to predict the fatigue life, thickness and weight of shot peened EN45A spring steel leaf springs, based on stress approach. The results obtained from simulation are found in accordance with the experimental results.

C) Analysis of composite leaf spring-

Senthilkumar M. and Vijayarangan S,(2007) In their paper describes static and fatigue analysis of steel leaf spring and composite multi leaf spring made up of glass fibre reinforced polymer using life data analysis. The dimensions of an existing conventional steel leaf spring of a light commercial vehicle are taken and are verified by design calculations. Static analysis of 2-D model of conventional leaf spring is also performed using ANSYS 7.1 and compared with experimental results.

(Hiroyuki Sugiyama, Omar M.A, et al. 2006). Develop nonlinear elastic leaf spring model for multibody vehicle systems. In this investigation, a nonlinear elastic model of leaf springs is developed for use in the computer simulation of multibody vehicle systems. In the leaf spring model developed in this investigation, the distributed inertia and stiffness of the leaves of the spring are modeled using the finite element floating frame of reference formulation that accounts for the effect of the nonlinear dynamic coupling between the finite rotations and the leaf deformation. (Arora V, Aggarawal M.L, et al.2011). Did comparative Study of CAE and Experimental Results of Leaf Springs in Automotive Vehicles. The work is carried out on the front end leaf spring of a commercial vehicle. The objective of this work is to carry out computer aided design and analysis of a conventional leaf spring, with experimental design considerations and loading conditions. This conventional leaf spring model consists of 37 parts. The material of the leaf spring is 65Si7.The CAD model of the leaf spring is prepared in CATIA and analyzed using ANSYS. The CAE analysis of the leaf spring is performed for the deflection and stresses under defined loading conditions, using ANSYS. The experimental and CAE results are compared for validation.

(Ganesan K , Kailasanathan C, et al. 2015).Did analysis of Composite Leaf Spring Enhanced With Nanoparticles. Weight reduction is now the main issue in automobile industries. In this work due to reduce the weight of steel spring with composite leaf spring due to high strength ratio is need to improve. The main aim is to compare to the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring at rated-load and over-load condition. The analysis has been carried out for the leaf spring made up of steel and Composite materials. Composite specimens are fabricated with two different staking sequences like the (resin with clay and enhanced with Nanoparticles).

The thickness and width for constant cross section is maintained on the moulding techniques.

(Triveni Z, Amara Babu B, et al 2016). Studied finite element analysis on leaf spring made of composite material. A leaf spring is a simple form of spring commonly used for the suspension in wheeled vehicles. Weight reduction can be achieved by designing new materials and sophisticated manufacturing processes.

III. CONCLUSION

This review paper gives the brief information about the work carried out on the composite leaf spring.In that firstly the material selection is the important parameter after that design,analysis and optimization on automotive composite leaf spring were discussed. Also in this paper the conventional steel leaf spring will be compared to the composite leaf spring for vehicles. Also some analysis will be performed by researchers such as, static analysis,fatigue analysis,shock analysis,modal analysis were performed using analytical method.Some researchers were performed numerical and experimental analysis.Also some researchers were used software packages such as CATIA,PRO-E,ANSYS.As per researchers the composite material is efficient and suitable for leaf springs in light motor vehicles.As compare to conventional steel leaf springs the composite material leaf spring are more efficient and beneficial for the light passenger vehicles.

REFERENCES

[1] Senthilkumar and Vijayarangan, “Analytical and Experimental studies on Fatigue life Prediction of steel leaf spring and composite leaf multi leaf spring for Light passanger vehicles using life data analysis” ISSN: 1392-1320, material science ,Vol. 13 No.2 (2007).

[2] Roselita Fragoudakis, Georgios Savaidis , NikolaosMichailidis, “Optimizing the development and manufacturing of 6SiCr7 leaf springs”,International Journal of Fatigue 103 (2017),pp. 168–175.

[3] Hiroyuki Sugiyama , Ahmed A. Shabana , Mohamed A. Omar , Wei-Yi Loh , “Development of nonlinear elastic leaf spring model for multibody vehicle systems”, sciencedirect,Comput. Methods Appl. Mech. Engg. 195 (2006),pp. 6925–6941.

[4] Vinkelarora, “A Comparative Study of CAE and Experimental Results of Leaf Springs in Automotive Vehicles”, International Journal of Engineering Science and Technology (IJEST), ISSN : 0975-5462, Vol. 3,September (2011).

[5] J.J. Fuentes , H.J. Aguilar , J.A. Rodriguez, E.J. Herrera, “Premature fracture in automobile leaf springs”, sciencedirect Engineering Failure Analysis 16 (2009),pp. 648–655.

[6] Krishan Kumar, M.L.Aggarwal, “Optimization of Various Design Parameters for EN45A Flat Leaf Spring”,ScienceDirect, Materials Today: Proceedings 4 (2017),pp. 1829–1836.

[7] Keshavamurthy Y. C, Chetan H. S, Dhanush C.&NithishPrabhu T, "Design and finite element analysis of hybrid composites mono leaf spring, International Journal of Mechanical and Production Engineering Research and Development", (IJMPERD), ISSN 2249-6890 Vol. 3, Issue 3, August(2013), pp. 77-82

[8] K. Ganesan , C. Kailasanathan , Y. Kumarasamy, "Analysis of Composite Leaf Spring Enhanced With Nanoparticles", Carbon – Science and Technology, ISSN 0974 – 0546,December 2015.

[9] Z. Triveni, B. Amara Babu, "Finite element analysis on leaf spring made of composite material", IJARSE,Vol-5,Issue No-4, April 2016.

[10] Ms. Surekha S. Sangale, Dr. KishorB. Kale, Dighe Y S, " Design Analysis of Carbon/Epoxy Composite Leaf Spring", International Journal of Research in Advent Technology (E-ISSN: 2321-9637),March 2015.

[11] AL-Qureshi H.A, "Automobile Leaf springs from composite materials", Journal of Material Processing Technology, 118, (2001),pp. 58-61.

[12] Jadhavk.k. and Dr.Dalu R.S, "Design and analysis of composite leaf spring",IJRMET,Vol.4,October (2014).

[13] Shaikh N.S and Rajmane S.M, "Modelling and analysis of suspension system of TATA SUMO by using composite material under the static load condition by using FEA",IJETT,ISSN:2231-5381,Vol.2,June (2014).