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DYNAMIC ANALYSIS OF FRP LEAF SPRING--CRITICAL REVIEW

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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.

I. INTRODUCTION

Suspension systems have been widely applied to vehicles, from the horse-drawn carriage with flexible leaf springs fixed in the four corners, to the modern automobile with complex control algorithms. The s suspension of a road vehicle is usually designed with two objectives; to isolate the vehicle body from road irregularities and to maintain contact of the wheels with the roadway. Isolation is achieved by the use of springs and dampers and by rubber mountings at the connections of the individual suspension components. From a system design point of view, there are two main categories of disturbances on vehicle, namely road and load disturbances. Road disturbances have the characteristics of large magnitude in low frequency such as hills and small magnitude in high frequency such as road roughness. Load disturbances include the variation of loads induced by accelerating, braking and cornering. Therefore, a good suspension design is concerned with disturbance rejection from these disturbances to the outputs. The suspension system requires an elastic resistance to absorb the road shocks and this job is fulfilled by the suspension springs

The light weight engineering becomes more and more import. Especially 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 is determining the constantly increasing demand of efficient or high performance products. 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. Life of leaf spring can be achieved mainly by introducing the new material, changing design parameter and manufacturing processes.

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, and The strength to weight ratio is higher for composite leaf spring eye 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.

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 Babu et.al. [6] in addressed the leaf spring analysis with eyes using FEA. They have estimated the deflection, stress and mode frequency induced for custom designed leaf spring with different eyes like viz., Berlin and upturned eyes with different materials at different section .The natural frequencies of various parametric combinations are compared with the excitation frequency 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] Compared performance analysis for E-glass/epoxy, C- glass/epoxy, S-glass/epoxy material. 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. 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-misses 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] focused modal and harmonic analysis of leaf spring using composite materials.. Composite materials i.e. E-glass/epoxy, graphite/epoxy, carbon/epoxy, Kevlar/epoxy are considered. Modal analysis is carried out to extract first five modes and computational results have been validated with analytical one. 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.

Meghavath. Peerunaik et al. [11], the objective work was to estimate the deflection, stress and mode frequency induced in the leaf spring of an army jeep design by the ordinance factory. The leaf spring has been modeled using solid tetrahedron 4 – node element. By performing static analysis it is concluded that the maximum safe load is 4000 N for the given specification of the leaf spring. These static analysis results of mono composite Carbon Epoxy leaf springs are compared to steel leaf spring. The stresses in the composite leaf spring are much lower than that of the steel spring. The composite spring can designed to strengths and stiffness much closer to steel leaf spring by varying the layer configuration and fiber orientation angles. The major disadvantages of composite leaf spring are the matrix material has low chipping resistance when it is subjected to poor road environments which may break some fibers in the lower portion of the spring. This may result in a loss of capability to share flexural stiffness. Composite leaf

springs made of polymer matrix composites have high strength retention on ageing at severe environments. The steel leaf spring width is kept constant and variation of natural frequency with leaf thickness, span, camber and numbers of leaves are studied. It has been observed that the natural frequency increases with increase of camber and almost constant with number of leaves, but natural frequency decreases with increase of span. The natural frequencies of various parametric combinations are compared with the excitation frequency for different road irregularities. 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 leaves.

Stephan Krall [12] the paper deals with the dynamic behavior of CFRP leaf springs.Three different composite springs were investigated and compared. The composite design is calculated via classical lamination theory and the manufacturing was done by hand lay-up and autoclave. An important aspect for spring elements is the behavior at different thermal conditions. Therefore one of the test bodies was investigated at low temperature. And the suitability of the analytical calculation of the Euler – Bernoulli beam theory was also investigated Both measurements – excitation by shaker and impact excitation – is given by the modal damping ratio correlating to the resonance frequency of the test bodies. There were noticeable differences between the results of the shaker excitation and the impact testing due to no physical connection between the excitation and the structure when performing the impact test..The best solution to determine the material properties and the dynamic characteristics particularly for light weight structures like the leaf spring bodies is an excitement by an impulse. Another result is the confirmation of the dependence between dynamic behavior and temperature. At lower temperatures the modal damping increases the analytical calculation has shown that CFRP springs can be calculated like a homogeneous body with constant Young's modulus providing a good approximation. Optimization in the construction of simple composite structures can be done by using the Euler – Bernoulli beam theory.

Adapa. Mahanth Kumar et al. [13]. The objective of the project is to replace the multi-leaf steel spring by mono composite leaf spring for the same load carrying capacity and stiffness by compare stresses and frequencies. Mono-composite leaf spring is designed for the same design specification except thickness so as to obtain the same stiffness for the same load carrying capacity and boundary conditions. E-glass/epoxy, graphite/epoxy and carbon/epoxy have been considered. It is observed that the stress in E-Glass / Epoxy is less than the stress in steel as well as other composite leaf springs. So from both the stiffness point of view and based on stress, E-Glass / epoxy can be used as better alternative.

II. 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. The springs undergo the fluctuating loading over the whole span of service life. In addition, various Design softwares like ANSYS, Pro-E, CATIA, Autodesk Inventor, etc., have been used for performing the stress analysis of mechanical springs. Almost in all of the above cases, fatigue stress, shear stress, maximum displacement calculation, play significant role in the design of mechanical springs. Comparison of the theoretical results obtained by the shear stress equation and Finite Element Analysis (FEM) of springs provides the better solution of the problems arising in the existing design of the mechanical spring. In future, it will help the designers for predicting the safe design of mechanical springs used in the automobiles to get better and comfortable ride.

The optimized leaf spring can be achieved by changing the material, changing the physical parameters like Span of the leaf spring, width of the leaf ,thickness of the leaf, number of leaves. The study helps to understand more about the behavior of the spring by using CAE and give information to the manufacturer to improve the fatigue life of the spring by changing design parameter.

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