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Performance Analysis of Mono Composite Leaf Spring for Light Commercial Vehicle – A Review

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Abstract-*In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturer in the present scenario. Weight reduction can be achieved primarily by introducing better material, design optimization and efficient manufacturing processes. The introduction of fiber reinforced plastics (FRP) material has made it possible to reduce the weight of spring without any reduction on load carrying capacity. The achievement of weight reduction with adequate improvement of mechanical properties has made composite a very good replacement material for conventional steel. Selection of material is based on cost and strength of material. The paper gives brief look on the suitability of composite leaf spring on vehicles and their advantages.*

Keywords-*Mono composite leaf spring, Composite material, Weight reduction, Glass fibre reinforced plastic (GPRF)*

I. INTRODUCTION

The suspension of leaf spring is one of the potential items for weight reduction in automobile as it accounts for ten to twenty percent of the unsprung weight. The automobile industries have shown increased interest in the replacement of steel with composite for manufacturing leaf spring because of low weight. This helps in achieving the vehicle with improved riding qualities. The introduction of composite materials has made it possible to reduce the weight of the leaf spring without any reduction on 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. Use of composite material as leaf spring, not only results in the reduction of weight but also ensures better safety and cost reduction.

II. LITERATURE REVIEW

GulurSiddaramanna Shiva Shankar et al.[1] studied a mono composite leaf spring with varying width and varying thickness is designed and manufactured. Computer algorithm using C-language has been used for the design of constant cross-section leaf spring. The results showed that an spring width decreases hyperbolically and thickness increases linearly from the spring eyes towards the axle seat. The experimental test are carried on both steel and composite leaf spring and compared the result. It is observed that composite leaf spring is more superior than steel with a large weight reduction.

B.B. Deshmukh et al.[2] in this paper gives the brief look on the suitability of composite leaf spring on vehicles and their advantages. The material selected is glass fibre reinforced plastic (GFRP) and the epoxy resin can be used which is more economical to reduce total cost of composite leaf spring with similar mechanical and geometrical properties to the multi leaf spring. The weight of the leaf spring is reduced considerably about 74 % by replacing steel leaf spring with FRP leaf spring. Besides the reduction of weight, the fatigue life of composite leaf spring is predicted to be satisfactory. Thus, the objective of reducing the unsprung mass is achieved to a larger extent. The stresses in the GFRP leaf spring are much lower than that of the steel spring.

ThippeswamyEkbote et al.[3] studied a double tapered mono leaf fibre reinforced composite leaf spring is developed to replace the nine leaf steel spring. The main consideration is given to the optimal design of the geometry of E-glass/epoxy composite leaf spring. A comparative study has been made between composite and steel leaf spring with respect to weight and strength. The comparison of analysis results with analytical values from basic design equations of multi leaf steel spring will yield a maximum variation of 6% in deflection and 4% in stress (VonMises) values.

Prof. Dr. Muhsin J. Jweeg et al.[4] showed experimental and theoretical study of composite materials reinforcement fiber types are presented. The main conclusions of this work are the best modulus of elasticity for composite materials are unidirectional composite materials in longitudinal direction and woven composite materials in any direction. The powder, particle, mats, and short fiber composite materials may be give isotropic properties of composite materials. With depend on resin materials properties. The variable of matrix materials affect the properties in powder, short, and mats composite materials more than in properties of woven and unidirectional composite materials.

Unidirectional composite materials gives minimum modulus of elasticity in transverse direction compares with other composite materials types.

Jadhav Mahesh V et al.[5] studied the achievement of weight reduction with adequate improvement of mechanical properties has made composite a very replacement material for convectional steel. From the comparative study, it is seen that the composite leaf spring are higher and more economical than convectional leaf spring. After prolonged use of conventional metal Coil Spring, its strength reduces and vehicle starts running back side down and also hits on the bump stoppers (i.e. Chassis). This problem is entirely removed by our special purpose Composite leaf Springs.

R D V Prasad et al.[6] showed that with development of analytical formulation for composite leaf spring and comparing the obtained results with the conventional steel leaf spring with 4 leaves. When maximum load is applied on the steel leaf spring, the maximum stress is greater than that of FRP leaf spring. Even under the maximum load, the maximum stress in the FRP is within the allowable limit. The weight reduction has greater influence in noise and vibration characteristics. Glass fibers are for manufacturing instead of carbon due to low cost.

AmolBhanage et al.[7] showed comparative simulation results of E-Glass Epoxy mono composite leaf spring for different layup as well for different thickness condition. First, simulation results have been performed for SAE 1045-450-QT steel material from weight saving and stress reduction point of view. Secondly, comparative simulation analysis performed between [0-45-(-45)-90-0], [0-45-(-45)-0], [0-0-45-(-45)-0] and [0-45-90] layup with different thickness from 9 mm, 10 mm, 12 mm, 13mm and 15 mm , considered according to selection of each layup thickness. The design and comparative simulation analysis was done in ANSYS Software. Similar mechanical properties for E-Glass epoxy composite material were considered for all simulation procedure. The design constraints and meshing were also being similar for all conventional and composite models of leaf spring.

ParkheRavindra et al.[8] in this paper describes design and analysis of composite mono leaf spring. A composite mono leaf spring with Carbon/Epoxy composite materials is modelled and subjected to the same load as that of a steel spring. Compared to mono steel leaf spring the laminated composite mono leaf spring is found lesser stresses and weight reduction of 22.5% is achieved. Based on the results, it was inferred that carbon/epoxy laminated composite mono leaf spring has superior strength and stiffness and lesser in weight compared to steel material considered in this investigation.

AmolBhanage et al.[9] studied the objective to present a design and simulation study on the fatigue performance of a glass fibre/epoxy composite leaf spring through design and finite element method and prove the reliability of the validation methods based only on simulation. Due to weight reduction and stress, stiffness criteria, multi steel leaf spring is proposed to be replaced with E- Glass Epoxy composite leaf springs. This paper will help to understand linear static behaviour of the composite leaf spring and simulation data to improve the fatigue life of the leaf spring using Computer Aided Engineering tool.

Edward Nikhil Karlus et al.[10] showed that as per the outcome obtain , by substituting the usual (55Si2Mn90) steel material by composite material (Carbon- Epoxy) we can decrease the stress produced in the leaf spring and moreover we anticipate that by substituting the material the enhanced comfort level throughout the spring can be accomplished or in other word it concentrated the total deflection of the leaf spring.By the reduction of weight and the less stresses, the fatigue life of Carbon- Epoxy composite leaf spring is to be higher than that of steel leaf spring.

ParkheRavindra et al.[11] studied that mono composite leaf spring with Carbon/Epoxy composite materials is modelled and subjected to the same load as that of a steel spring. The design constraints were stresses and deflections. The stresses induced in the Carbon/Epoxy composite leaf spring are 42% less than that of the steel spring nearly. The finite element solutions show the good correlation for total deformation with analytical results. Study demonstrates that the composite can be used for leaf spring for the light vehicle and meet the requirement, together with the sustainable weight reduction. A weight reduction achieved in mono composite leaf spring is about 22.15%.

Prof. N.V. Hargude et al.[12] showed that it is possible to easy manufacturing a leaf spring using E glass epoxy glass fiber. As per the point of weight reduction it is possible by using composite material. Ride comfort and life of Composite Leaf Springs are also more when compared to Steel Leaf Springs. The material selected was glass fiber reinforced polymer (E-glass/epoxy), carbon epoxy and graphite epoxy is being used for making an mono leaf spring. Here it is selected and analysed with the objective of minimizing weight of the composite leaf spring as compared to the steel leaf spring.

M. P. Palaskar et al.[13] studied that if the thickness is varied parabolically along the length of the leaf spring, better results can be obtained.Material saving up to 25% can be achieved by parabolic variation in thickness along the length of the leaf spring. In other words distribution of stress of leaf spring can be improved (it becomes more uniform) after optimization. Utilization of material is improved due to optimization. Riding comfort of passengers is improved due to reduction in unsprung mass of the vehicle. More deflection can be obtained after optimization thus increasing the riding comfort further.

Prof. N.V. Hargude et al.[14] showed thatthe objective is to review various techniques used to analyses of composite mono leaf spring for the load carrying capacity, stiffness and weight savings of composite leaf spring. The dimensions of an existing conventional steel leaf spring of a heavy commercial vehicle are taken same dimensions of conventional leaf spring are used to fabricate a composite multi leaf spring using e-glass/epoxy, c- glass/epoxy, s-lass/epoxy unidirectional laminates.Under the dynamic load conditions natural frequency and stresses of steel leaf spring and composite leaf spring are found with the great difference. The natural frequency of composite material is high than the steel leaf spring. Reductions in weight about 85 to 90% in composite leaf spring are observed than conventional with same level of performance.E-glass epoxy is better than using Mild-steel as though stresses are little bit higher than mild steel, E-glass epoxy is having good yield strength value and also epoxy material components are easy to manufacture and this having very low weight while comparing with traditional materials. S-glass is having better results while comparing with E-glass and mild steel.CAE tools provides a cost effective and less time consuming solution in comparison with the experimental testing but the results may vary in the specified range.

Jaydeep J. Patil et al.[15] in their paper discussed the brief look on the suitability of composite leaf spring on vehicles and their advantages. Compared to the steel spring, the composite spring has stresses that are much lower, the natural frequency is higher and the spring weight is nearly 85 % lower with bonded end joint and with complete eye unit. The attempt has been made to fabricate the FRP leaf spring economically than that of conventional leaf spring. The leaf spring is design by considering as it is behave like a cantilever beam. For the analysis purpose ANSYS software is selected as it gives good result. Advantages such as reduction in noise, increasing in comfort ride.

Mohammed Mathenulla Sharif et al.[16] studied in this paper is to design and analyse composite mono leaf spring of constant width and thickness having the same bending stiffness of semi-elliptical laminated leaf spring. Stress analysis was done by using analytical method and results obtained by analytical methods are compared with ansys. The results obtained by analytical methods showed good agreement with ansys results. A Tsai-Hill failure criterion was used to check whether stresses are within reasonable levels for each ply. The stresses induced in the composite leaf springs were found to be 33.79% less compared to steel leaf spring. When steel leaf spring is replaced by composite leaf spring a weight reduction of 77.29% is obtained , 2.23 times higher natural frequency, 1.371 times more strain energy storage capacity, 33.79 % lesser stress and lesser value of spring rate is obtained in the composite leaf spring compared to steel leaf spring

III. CONCLUSION

A literature survey shows that existing steel material can be replaced with the composites without compromising life, reliability and performance of leaf spring. In this work, selection of different composite material based on requirement of properties of leaf spring is made. E-glass epoxy is better than using Mild-steel as though stresses are little bit higher than mild steel, E-glass epoxy is having good yield strength value and also epoxy material components are easy to manufacture and this having very low weight while comparing with traditional materials. Riding comfort of passengers is improved due to reduction in unsprung mass of the vehicle.

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