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DESIGN AND DEVELOPMENT OF COMPOSITE LEAF SPRING - REVIEW

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Abstract

The current trend in automotive industry is to produce vehicles with lighter materials and economic cost yet ensuring the safety of the occupants. Weight reduction can be achieved by primarily by the introduction of better material, design optimization and better manufacturing processes. In this main focus is to review all such work in which the weight reduction of the vehicle was achieved by considering leaf spring. Composite materials are one of the material families which are having very good weight to strength ratio suggesting many author. Different methods of manufacturing, design and analysis leaf spring area also discussed. It was shown that the weight reduction can be easily achieved by there are more aspects which should be consider i.e. new composite material composition, cost, manufacturing process.

Keywords: Composite Leaf spring ,material E-glass/Epoxy, weight reduction.

1. Introduction

In automobile small commercial vehicle out of many components one of the components of automobile which can be easily replaced is leaf spring. A leaf spring is a simple form of spring, commonly used for the suspension in wheeled vehicles. The suspension of leaf spring is the area which needs to focus to improve the suspensions of the vehicle for comfort ride. The suspension leaf spring is one of the potential items for weight reduction in automobile as it accounts for 10 to 20% of un spring weight.

It is well known that springs are designed to absorb shocks. So the strain energy of the material becomes a major factor in designing the springs. The introduction of composite material will make it possible to reduce the weight of the leaf spring without reduction in load carrying capacity and stiffness. Since the composite material have high strength to weight ratio and have more elastic strain energy storage capacity as compared with steel.

The relationship of specific strain energy can be expressed as

$$U=1/2 * \sigma^2/\rho E$$

It can be easily observed that material having lower density and modulus will have a greater specific strain energy capacity. Thus composite material offer high strength and light weight. In this work, leaf springs of automobile small commercial vehicle TATA ACE family is considers for further investigation.

The suspension quality can be improved by minimizing the vertical vibrations, impacts and shocks due to road irregularities which create the uncomfortable ride.

2. Literature Review

Taking into consideration Composite mono leaf spring, the extensive literature survey has been made by referring books, technical paper, journals, and conference chapter and from internet. Following are some of the finding from literature survey.

Syambabu Nutalapati, [1] had studied the four-leaf steel spring used in the rear suspension system of light vehicle of Mahindra "Model -Commander 650 DI". The objective was to obtain a spring with minimum weight of the composite leaf spring as compared to steel leaf spring, That is capable of carrying given static external forces without failure. The design constraints were stresses and displacements. In this study they concluded that single composite leaf spring is designed and it is shown that the resulting design and simulation stresses are much below the strength properties of material satisfying the maximum stress failure criterion. Compared to the steel spring, composite spring has stresses that are much lower, the natural frequency is higher and the spring weight without eye units is nearly 85% lower. The stresses in the composite leaf spring are much lower than that of the steel spring. The natural frequency of composite leaf spring is higher than that of the steel leaf spring and is far enough.

Joo-teck Jeffery KUEH. et.al [2] had investigated the static and fatigue behaviours of steel and composite multi-leaf spring using the ANSYS V12 software. The dimensions was kept same for steel and multi leaf spring of a light commercial vehicle. They were used to design composite multi leaf spring for two material, E-glass fiber/epoxy and E-glass fiber/vinyl ester. They investigate and conclude that, the maximum bending stresses in composite leaf spring are much lower than that of steel spring and fatigue of composite springs was proven to be 2 to 4 times higher than that of steel leaf spring. E-glass/epoxy performance was better than that of vinyl ester.

H.A.Al-Qureshi [3] had selected the suspension spring of the light trucks (jeep). Investigate that stresses on parabolic mono composite leaf spring with variable thickness spring of GFRP, and conclude that mono composite leaf spring had lower flexure stress but higher nominal shear stress. This study demonstrate that composite material can be used for light commercial vehicles with substantial weight reduction.

Abdul Rahim Abu Talib , et.al [4] had studied the composite material elliptical spring based on spring stiffness, long fatigue life and shear stress parameter. The study found that composite mono elliptical spring can be used for light and heavy trucks with substantial weight reduction. The results showed that ellipticity ratio significantly influenced the design parameter. From studied various behavior between Steel and composite leaf spring, better fatigue life of composite leaf spring than steel.

Ivo cerny, et.al [5] done the most important results of selected experimental programmes on static and fatigue strength of heavy loaded components and joints made of glass reinforced plastic (GRP) composites. A detailed analysis of fatigue tests, some further links like connections between total fatigue life and initial stiffness or initial temperature increase gradient were indicated. Sudden break was mostly characteristic for a defect material with insufficient wet out with different bubbles and voids. In case of an important material structure, fatigue cracking started in the weakest points of the microstructure and were therefore strongly localized.

On the contrary, fatigue damage of GRP components with perfect microstructure was quite a global process distributed to a high volume of material and was then connected with gradual change of stiffness.

Dipendra Kumar Roya, et.al [6] done numerical analysis of large deflection of prismatic cantilever beams for various types of material properties with a transverse load at free end, to study the displacement response of leaf springs. In this paper they had concluded that due to adequate improvement of mechanical properties it is observed that FGM leaf springs are more economical than conventional leaf springs. The present method, being based on an iterative computational technique, may be used to extend the problem in the area of thermo-elasticity.

Pinaknath Dewanji, [7] done design and analysis of multi layer composite leaf spring. The analysis had conducted with ANSYS-12 software with help of statics structural tool. In this work carried out composite leaf spring reduce the weight by 67.88% for E-Glass/Epoxy. E-Glass/Epoxy composite leaf spring can be suggested for replacing the steel leaf spring both from stiffness and stress point of view. Totally it was concluded that composite leaf spring is an effective replacement for existing steel leaf spring in vehicles.

E.Mahdi, et.al[8] had worked for the influence of ellipticity ratio on performance of woven roving wrapped composite elliptical series of experiments were conducted for composite elliptical springs with ellipticity ratios (a/b) ranging from one to two. In they worked conclude that composite elliptical spring can be used for light and heavy trucks and meet the requirements, together with substantial weight saving. The results shown that ellipticity ratio significantly influenced spring stiffness and failure loads. Composite elliptic spring with ellipticity ratios of a/b =2.0 displaced the highest spring stiffness.

Jiashi Wang , et al [9] had investigated on the mono composite leaf spring. The rectangular cross section had used mono composite leaf spring in commercial vehicle. They had measured of the spring stiffness and maximum load carrying capacity were conducted on mono composite leaf spring manufactured by hot molding process method, and they are 157.2 N/mm and 34,280 N respectively. They had compared result with obtained from experimental and FEA , it can be seen that the errors are 1.56% for the spring stiffness and 0.82% for the capacity load, and main performance of fabricated composite leaf spring have better agreement with the designed requirements.

V Sampath, et.al [10] had studied the suspension leaf spring to reduce the weight of the leaf spring by using composite materials such as Epoxy/E-glass and Epoxy carbon. In their work consider that using composite material for manufacturing components of an automobile to reduce the weight without compromising quality and reliability. In this they had concluded that, In order to reduce the weight of the component Epoxy/E-carbon was better compared to variable thickness of steel.

M. Venkatesan, et.al [11] had worked to compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. The design constraints are stresses and deflections. In this they had concluded that composites can be used for leaf springs for light weight vehicles and meet the requirements, together with substantial weight savings, with the help of comparative study between composite and steel leaf spring with respect to weight, cost and strength. From the results, it was conclude that the composite leaf spring is lighter and more economical than the conventional steel spring with similar design specifications. Composite leaf spring reduces the weight by 85 % for E-Glass/Epoxy, over conventional leaf spring.

Ravi Kumar, et.al [12] had worked out by comparing the Glass-Fiber-Reinforced - Composite (GFRC) leaf spring with a Natural-Fiber-Reinforced Composite/Jute-Fiber – Reinforced – Composite (NFRC/JFRC) leaf spring. In this way this study concluded that Compared to the GFRC leaf spring, the NFRC Composite material spring has stresses much lower to steel .The NFRC leaf spring resulted reduction in deflection and stresses without compromising stiffness as experimentally and analytically. The weight of the leaf spring is reduced considerably about 75% by replacing steel and GFRP and Jute -E-Glass-Epoxy composite leaf spring thus the objective was reducing the un-sprung mass is achieved to larger extent.

Y.S. Kong, et.al[13] had worked out fatigue life assessment of the parabolic leaf spring is a significant aspect during the component design stage. In their work the fatigue life of spring design under variable amplitude loading(VAL). VAL signal gathered though measurement from various road conditions such as highway, curve mountain road and rough rural area road. Fatigue life of particular leaf spring design predicted using finite element (FE) stress-strain model together with VALs signal as load input. More conservative way they do that mean stress correction methods were applied. The results indicate that fatigue life of leaf spring lowest during rough road mission, followed by curve mountain road and smooth highway road respectively.

U. S. Ramakanth et.al [14] had carried out work on multi leaf springs having nine leaves used by a commercial vehicle. The material had selected for leaf springs is 65Si7 (SUP9), composite leaf springs and hybrid leaf springs. Fatigue analysis of leaf springs was carried out for three different material stated above. In this they had concluded that Under the same static load conditions the stresses in leaf springs are found with great difference with respective material properties. Stresses in composite leaf springs is found out to be less as compared to the conventional steel leaf springs. Conventional 65Si7 (SUP9) leaf springs were found to weight about 58.757kgs, while the composite leaf springs weighed only 19.461kgs, and the hybrid leaf springs weighed 41.14 kg for the same specifications.

Parkhe Ravindra, et.al [15] had worked on conventional steel leaf spring with mono composite leaf spring. They had select material for spring is Carbon/Epoxy composite material. They had modeled and subjected to the same load as that of a steel spring. The design constraints were stresses and deflections. In this work they had done comparative study between composite leaf spring and steel leaf spring with respect to weight and strength without change dimension parameter. By employing a composite leaf spring for the same load carrying capacity, they conclude that lower stresses and high in stifness in composite leaf spring rather than conventional steel spring, there is a reduction in weight of 22.5% than the steel spring.

Pankaj Saini, et.al[16]. They investigate in their worked to compare stresses and weight reduce of composite leaf spring with that of conventional steel leaf spring. They consider stiffness is design parameter. The material selected was 3 different type of composite material first one glass fiber reinforced polymer (Eglass/Epoxy), second one carbon Epoxy and third one graphite epoxy against conventional steel leaf spring. They targeted substantial weight reduction and same strength in suspension system replacing leaf spring with mono composite leaf spring. Composite mono leaf spring reduce the weight by 81.22% for E-Glass/Epoxy, 91.95% for Graphite/Epoxy, and 90.51% for Carbon/Epoxy over conventional leaf spring.

Ganesh, et.al [17] had found out the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. This work is carried out on multi leaf of commercial vehicle. In this work they had concluded that the leaf spring based on fiber glass reinforced epoxy has a lower mass compared with the leaf spring made up of SAE 9260.Total mass reduction obtains 22.46 kg (100.45%) by using composite material.

S.Rajesh, et.al [18] had worked on replacing the conventional leaf spring with composite leaf spring. A single leaf with constant cross sectional area similar to that of conventional leaf spring(CLS) in each case such as bidirectional glass fiber reinforced plastic (GFRP), bidirectional carbon fiber reinforced plastic (CFRP), bidirectional carbon-glass reinforced plastic (C-GFRP) and bidirectional glass-carbon reinforced plastic (G-CFRP) were fabricated by hand layup technique and tested by universal testing machine. By using universal testing machine, load per deflection and maximum load that a leaf spring can withstand were measured. They had concluded that, The composite leaf springs can take more amount of load than the conventional leaf spring for constant specified deflection. Also among the composite leaf springs, the glass – carbon composite leaf spring can take up more amount of load than others. The composite mono leaf spring reduces the weight by 71% for glass/epoxy, 70% by carbon/epoxy, 67% for carbon-glass/epoxy and 68% for glass-carbon/ epoxy over the conventional leaf spring. If these kind of composite leaf springs are replaced in the automobiles, an improved vehicle performance will be obtained with appropriate load bearing properties due to the lower weight.

3.Summary

As a lot of work has been done in designing of leaf spring which is discussed brief in this text, on the basis of study research paper. The weight of leaf spring reduced by using many different composite material E-Glass/Epoxy, and hybrid and much more. Many author suggested methods of design, manufacturing and analysis of composite leaf spring. After studying all available literature survey it s found that weight reduction can be done by using composite material leaf spring instead of conventional steel leaf spring. Therefore there is an immense scope for the future work regarding use of composite materials in composite leaf springs to reduce the overall weight of the vehicle.

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