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Static Analysis of Hybrid Composite Leaf Spring

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Abstract

Leaf spring is a simple form of suspension spring used to absorb vibrations induced during the motion of a vehicle. The automobile industry has shown increased interest in the replacement of steel leaf spring (65Si7) with hybrid composite leaf spring with Jute/E-glass/Epoxy due to high strength to weight ratio, higher stiffness, high impact energy absorption and lesser stresses. This research is aimed to investigate the suitability of natural and synthetic fiber reinforced hybrid composite material in automobile leaf spring application. By using natural fibers efforts have been made to reduce the cost and weight of leaf spring. A hybrid composite leaf spring with Jute/E-glass/Epoxy composite materials is modeled and subjected to the same load as that of a steel spring. The hybrid composite leaf spring has been modeled by their consideration. Static structural analysis of a leaf spring has been performed using ANSYS 14. Compared to steel leaf spring the laminated hybrid composite leaf spring weight reduction is achieved.

Keywords- leaf Spring.

Introduction

The automobile industry is exploiting composite material technology for structural components in order to obtain the reduction of weight without decrease in vehicle quality and reliability. Energy conservation is one of the most important objectives in any vehicle design and reduction of weight is one of the most effective measures for energy conservation as it reduces overall fuel consumption of the vehicle. The suspension leaf spring is one of the potential items for weight reduction in automobiles as it accounts for ten to twenty percent of the unsprung weight. The leaf spring should absorb vertical vibrations, shocks and bump loads by means of spring deflection so that the potential energy is stored in the leaf spring as strain energy and then released slowly. Thus elastic strain energy storage capacity is an important criterion while selecting the material for leaf spring. The specific elastic strain energy is inversely proportional to the density and young's modulus. The automobile industry has shown increased interest in the replacement of steel leaf spring with fiber glass composite leaf spring because FRP composites possess lower young's modulus, lower density and lesser weight as compared to steel. This research is an innovation in this field as it finds the suitability of natural fiber based hybrid composite material in leaf spring application. Recently natural fibers have been receiving considerable attention as substitutes for

synthetic fiber reinforcements such as glass in plastics due to their low cost, low density, acceptable specific strength, fairly good mechanical properties, eco friendly and biodegradability characteristics.

In this work, an attempt is made to develop a natural and synthetic fiber reinforced hybrid composite material with optimum properties so that it can replace the existing synthetic fiber reinforced composite material in automobile leaf spring application. Three dimensional models of leaf spring are prepared in catia v5. Static structural analysis of leaf spring models is performed in ANSYS 14 considering three different materials i.e. steel, Jute/E-glass/Epoxy. The leaf spring analysis is done in a range of 1KN to 5KN. Bending stresses deflections and strain energy are the results.

Literature survey

Many industrial visits, past recorded data shows that steel leaf springs are manufactured by EN45, EN45A, 60Si7, EN47, 50Cr4V2, 55SiCr7 and 50CrMoCV4 etc. These materials are widely used for production of the parabolic leaf springs and conventional multi leaf springs.

Leaf springs absorb the vehicle vibrations, shocks and bump loads (Induced due to road irregularities) by means of spring deflections, so that the potential energy is stored in the leaf spring and

then relieved slowly. Ability to store and absorb more amount of strain energy ensures the comfortable suspension system.

Many suspension systems work on the same principle including conventional leaf springs. However, for the same load and shock absorbing performance, conventional (steel) leaf springs use excess of material making them considerably heavy. This can be improved by introducing composite materials in place of steel in the conventional spring. Studies and researches were carried out on the applications of the composite materials in leaf spring. A composite mono leaf spring with an integral eye was manufactured and tested for the static load conditions. Fatigue life prediction was also done by authors so as to ensure a reliable number of life cycles of a leaf spring. Further, a leaf spring had been modelled in conventional way and simulated for the kinematic and dynamic comparatives. Cyclic creep and cyclic deformation was also studied. Efforts were taken for Finite Element Analysis of multi leaf springs. These springs were simulated and analyzed by using ANSYS 14. Premature failure in leaf springs was also studied so as to suggest remedies on application of hybrid composite leaf springs.

Methodology

The objective of the work is to design the hybrid composite leaf spring for automobile suspension system and analyze it. This is done to achieve the following.

To replace steel leaf springs with Jute/E-glass/Epoxy composite leaf spring.

To achieve the substantial weight reduction in the suspension system by replacing steel leaf spring with hybrid composite leaf spring.

The leaf spring was designed in catia v5. Model is imported in ansys 14 for analysis by applying the load conditions.

After analysis a comparison is made between existing steel leaf spring and hybrid composite leaf spring in terms of deflections and stresses.

Materials

Materials employed in this study: 1. Steel 2. Jute/E-Glass/Epoxy 65Si7 is the most popular grade of spring steel being used in automobile leaf spring.

Table no.1 Mechanical Properties of 65Si7

Parameter	value
Young’s Modulus	2.1*10 ⁵ N/mm ²
Poisson’s Ratio	0.266
Tensile Strength	450 MPa
Density	7860 Kg/mm ³

Springs are designed to absorb and store energy and then release it. Hence, the strain energy of the material becomes a major factor in designing the springs. The relationship of the specific strain energy can be expressed as:

$$U = \frac{\sigma^2}{2\rho E}$$

Where, σ is the strength, ρ is the density and E is the young’s modulus of the spring material. It can be easily observed that material having lower modulus and density will have a greater specific strain energy capacity. Research has indicated that E-Glass/Epoxy has good characteristics for storing specific strain energy as E-glass has lower young’s modulus and lower density than steel. Hence, E-Glass/Epoxy is selected as the composite material. In this research work, a natural fiber i.e. jute is introduced in E-Glass/Epoxy to develop a hybrid composite material which can reduce the weight as well as cost of leaf spring.

Table no.2 Mechanical Properties of Jute/E-glass/Epoxy

Parameter	value
Young’s Modulus	21000 MPa
Poisson’s Ratio	0.22
Tensile Strength	185 MPa
Density	1460 Kg/mm ³

Modeling

CAD model designs with steel and hybrid composite materials of multi leaf spring are created in catia v5. In catia v5 it contains special tools in generating typical surfaces, which are later converted into solid models. For modelling the steel leaf spring, the dimensions of a conventional leaf spring of a light commercial vehicle are chosen.

Solid modeling of steel leaf spring

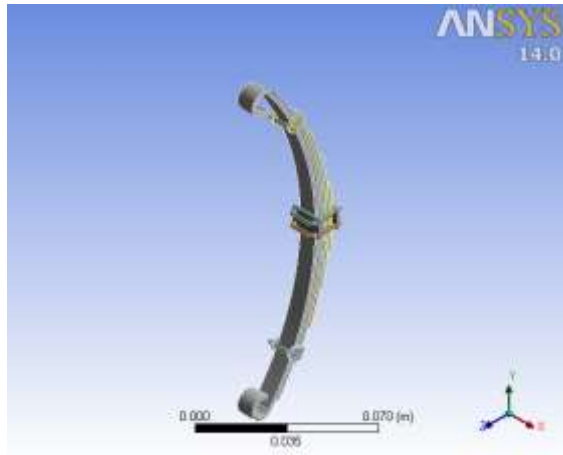


Fig 1 solid modeling of leaf spring

Analysis using ANSYS

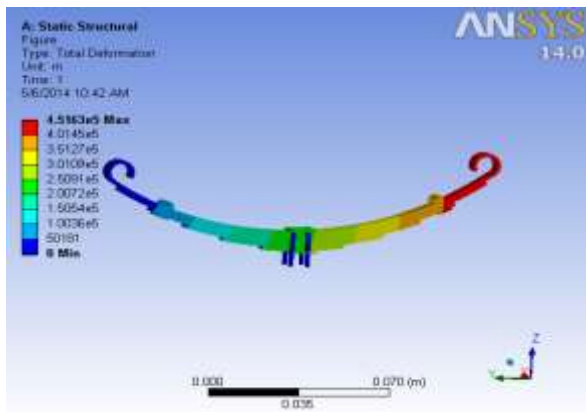


Fig 2 Deformation of steel leaf spring

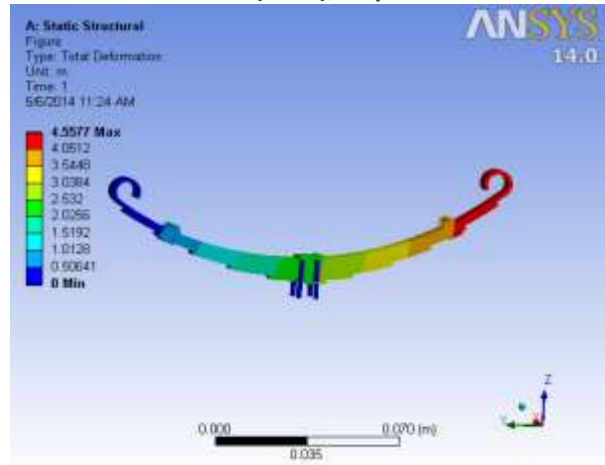


Fig 3 Deformation of Jute/E-glass/Epoxy

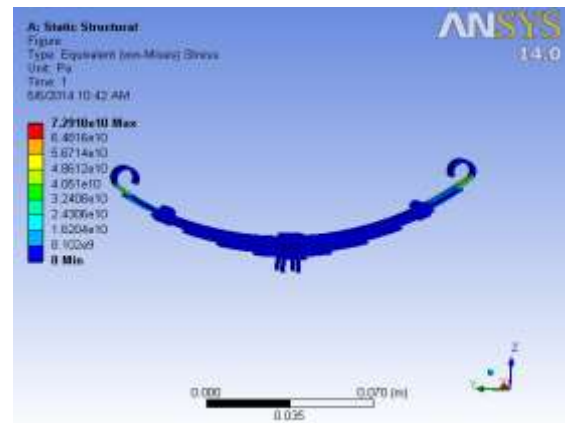


Fig 4 Stress analysis of Steel leaf spring

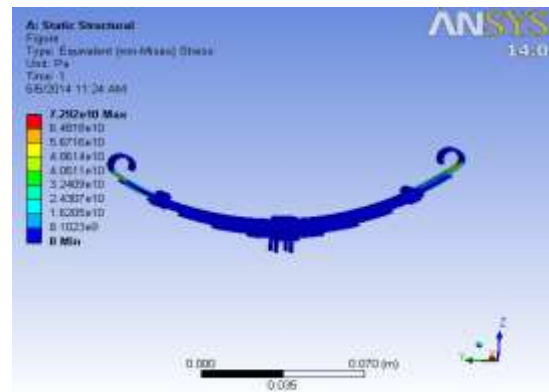


Fig 5 Stress analysis of Jute/E-glass/Epoxy

Table No.3 Comparative Analysis Of Stress And Deflection Of The Steel And Hybrid Composite Leaf Springs

Parameters	65Si7	Hybrid composite leaf spring
Force	5000 N	5000 N
Max Deflection	4.51e5 m	4.557 m
Max Stress	7.2918e10 Pa	7.292e10 Pa

Conclusions

Under the load conditions the deflection of steel leaf spring and hybrid composite leaf spring are found with the great difference.

Deflection of hybrid composite leaf spring is less as compared to steel leaf spring with the same loading condition.

The stress of steel and hybrid composite leaf spring is approximately same. From the results, it is observed that the hybrid composite leaf spring is lighter and more economical than steel leaf spring.

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