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Vibration Analysis Composite Material Mono Leaf Spring

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Abstract: **This project describes design and experimental analysis of composite leaf spring made of glass fiber reinforced polymer. The objective is 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. The dimensions of an existing conventional steel leaf spring of a light commercial vehicle are taken. Same dimensions of conventional leaf spring are used to fabricate a composite multi leaf spring using- Glass/Epoxy unidirectional laminates. Static analysis of 2-D model of conventional leaf spring is also performed using ANSYS 10 and compared with experimental results. Finite element analysis with full load on 3-D model of composite multi leaf spring is done using ANSYS 10 and the analytical results are compared with experimental results. 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 76.4% is achieved by using optimized composite leaf spring. The Automobile Industry has shown increase interest for replacement of steel leaf spring with that of composite leaf spring, since the composite material has high strength to weight ratio, good corrosion resistance and tailor-able properties. The paper describes static analysis of steel leaf spring and laminated composite Multi leaf spring. The objective is to compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. The dimensions of an existing conventional steel leaf spring of a Light design calculations. Static Analysis of 3-D model of conventional leaf spring is performed using ANSYS 11.0 and hypermesh. Same dimensions are used in composite multi leaf spring using carbon/Epoxy and Graphite/Epoxy unidirectional laminates. The load carrying capacity, and weight of composite leaf spring are compared with that of steel leaf spring**

Keywords: **Composite materials, design constrain, leaf spring, material property, static ANSYS.**

1. INTRODUCTION

In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturers in the present scenario. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. The suspension leaf spring is one of the potential items for weight reduction in automobiles as it accounts for 10% - 20% of the unspring weight.

This achieves the vehicle with more fuel efficiency and improved riding qualities. The introduction of composite materials was made it possible to reduce the weight of leaf spring without any reduction on load carrying capacity and stiffness. Since, the composite materials have more elastic strain energy storage capacity and high strength to weight ratio as compared with those of steel, leaf steel multi springs are being replaced by mono-leaf composite springs.

The composite material offer opportunities for substantial weight saving. But are not always cost effective over their steel counter parts.

Leaf spring are of the oldest suspension component they are still frequently used. The current leaf spring is multiple leaf spring types with a steel material. It has high weight, low natural frequency, high corrosion, more noise. Therefore current multiple leaf spring needs to be changed replaced by mono composite (Carbon Glass epoxy) leaf spring which we will find high natural frequency, low weight etc. The maximum stress produced at the cylindrical joint than fixed joint.

Therefore stress analysis of composite material mono leaf spring will be carried out. The result of finite element method will be verified with analytical calculation. to compare the natural frequency by FFT analyzer with FEA. comparison of FEM results of composite carbon fiber leaf with steel springs weight load ,deflection ,natural frequency & stress

1.2 Present Theories And Practices:

Composite materials are ideal for structural application where high strength to weight and stiffness to weight ratio are required. Aircraft and spacecraft are typical weight sensitive structures in which composite materials are cost effective. Composite materials are basically hybrid materials formed of multiple materials in order to utilize their individual structural advantages in a single structural material. The composite material then has the properties of the two materials that have been combined. The key is the macroscopic examination of a material wherein the components can be identified by the naked eye. The advantage of composite materials is that, if well designed, they usually exhibit the best qualities of their components or constituents and often some qualities that neither constituent possesses. Some of the properties that can be improved by forming a composite material are Strength-Fatigue life Stiffness-Temperature-dependent behavior-Corrosion resistance-Thermal insulation-Wear resistance-Thermal conductivity-Attractiveness. Acoustical insulation-Weight The Automotive industry has been a major factor in the development and application of composite material. By weight, about 8% of today's automobile parts, including bumpers, body panels and doors are made of composites. Ceramic composite engine which would not require water-cooling. Chopped glass fiber-reinforced polymers have been used extensively in body panels, where stiffness and appearance are the principal design criteria. It is very important to design the composite material by arranging volume fraction which gives optimum results at low cost and low weight. The objective of this dissertation is to analyze experimentally and by finite element method the mechanical behavior of leaf spring made of ductile and composite material.

2. LITERATURE SURVEY

An advanced book on mechanics of composite material by **R. Jones** covers applications of composite materials and micromechanical and macro mechanical behavior of lamina and laminates as well as design of composite structure.

W.J. et.al [1] It Based on a generalized cumulative damage approach with a stochastic process describing "initial damage" for a material specimen, a broad class of statistical models for material strength is developed. the applicability of the general model is illustrated for three sets of strength data.

Daniel et.al [2] the results show unexpected transitions in fatigue resistance with fiber content and fabric architecture. Transitions to increased fatigue sensitivity have been related to fiber packing characteristics through detailed microscopy study. A novel high frequency apparatus using 9 impregnated strands. Material endurance limit has not been seen

Kin-tak et.al [3] A theoretical model to evaluate natural frequencies of composite beams, which are clamped at both ends with embedded pre strained SMA wires, is presented Change of strain in both the SMA wires and composite materials due to a strain recovery action of the pre strained SMA wires are considered in the model. According to the results shown in the theoretical predictions, it is found that the natural frequencies of the composite beams decrease with increasing the numbers of embedded SMA wires at a temperature below marten site finish temperature.

Akira et.al [4] the materials tested were glass/polyester composites, two types of carbon/polyester composites, and carbon and glass hybrid composites. The tests that were performed for this study are four-point-bending tests, tension tests, panel warping tests, and beam bend-twist coupling tests. The material properties of interest were basic longitudinal and transverse stiffness and strength, residual stress due to curing, and the effect of bend-twist.

Vinkel et.al [5] worked on design and analysis of single leaf spring under static loading conditions. They have prepared 3D model in CATIA and then CAE analysis has performed using ANSYS -11. From the results obtained from ANSYS, it was concluded that when same load is applied to standard and casted leaf spring equivalent stress reduction of 2.9% and increase in deflection of 5.44% is achieved.

Ranjit et.al [6] has used Glass –Epoxy leaf spring which has high natural frequency, low weight etc. The maximum stress produced at the cylindrically joint than fixed joint. The stress analysis of composite material mono leaf spring is carried out. The result of finite element method is verified with analytical calculation. Also compare the natural frequency by FFT analyzer with FEA. He concluded that 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. Conventional steel leaf spring has more weight as compared with E-Glass/Epoxy mono leaf spring and reduction in weight is up to 50% for the same level of performance

Vijaya. [7] In their research conducted the static and dynamic analyses of composite leaf spring for heavy vehicles.They have carried out modal and harmonic analysis experimentally and in ANSYS software. They concluded that S-glass epoxy is the best material to manufacture leaf spring.

Pankaj [8] carried out the research on design and analysis of composite leaf spring. They concluded from the static analysis results that there is a more displacement in the steel leaf spring and the corresponding displacements in E glass / epoxy, graphite/epoxy, and carbon/epoxy are more. And all the values are below the camber length for a given uniformly distributed load. They have used three composites E glass / epoxy, graphite/epoxy, and carbon/epoxy and found that among the three composite leaf springs; only graphite/epoxy composite leaf spring has higher stresses than the steel leaf spring.

3. SCOPE AND OBJECTIVES OF THE WORK

The suspension leaf spring is one of the potential items for weight reduction in automobiles. This project work focuses on using composite material for leaf spring of heavy vehicle for weight reduction without losing strength. The objective of present dissertation is to carry out finite element analysis of composite leaf spring and experimental validation of it.To study vibration characteristic of mono leaf spring. To compare between steel & epoxy carbon leaf spring vibration characteristics experimentally and FEM

3.1) Stress Analysis Using FEM:

The leaf spring subjected to loads while suspension. Due to the complex geometry, Stress analysis is done using Finite Element Method.

Following steps are followed for stress analysis

1. CAD model of leaf is prepared by using dimensions.

2. Finite element mesh is generated.

3. Stress analysis of model is done by using software ANSYS.

3.2) Experimental Validation:

A specimen rod of carbon fiber material is moulded & casted for UTM test

2. Following steps are followed for experimental validation.

3. Salection of location of deflection measurement.

4. Comparison of vibration charectestics of FEM and Experiment method.

3.3) Experimentation:

1. Bending test will be carried out to find stress & strain in bending of composite specimen.

2. Also find out natural frequency & compare by FFT analyzer with FEA

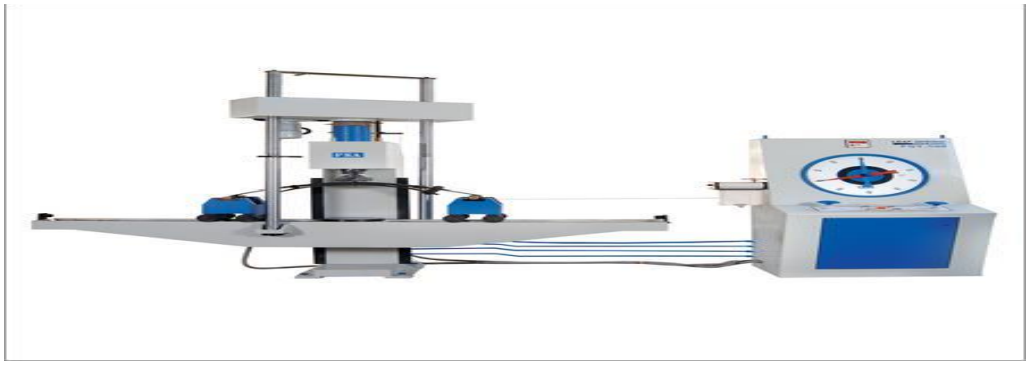

Fig.1 Leaf Spring Testing Machine to conduct similar test on sample specimen

4. METHODOLOGY OF PROBLEM SOLVING

The problem under consideration will be modeled through five approaches

1. 3-D CAD Modeling

2. 3-D Finite Element Meshing

3. Analytical Calculations

4. Finite Element Analysis (Structural, Static and Dynamic)

5. Experimental Validation

4.1) Available software:

1. AUTO CAD

2. CATIA

3. ANSIS

4. FFT analyzer, accelerometer and necessary instruments.

4.2 Computer Aided Engineering (CAE):

Here we define the analysis type and options, apply loads and initiate the finite element solution. This involves three phases:

1. Pre-processor phase

2. Solution phase

3. Post-processor phase

Table 4.2.1 The following table shows the brief description of steps followed in each phase:

Preprocessor Phase	Solution Phase	Post-Processor Phase
Geometry Definitions	Element Matrix Formulation	Post Solution Operations
Mesh Generation	Overall Matrix Triangularization	Post Data Print Outs(ForReport')
Material	(Wave Front)	Post Data
Contact Definitions		Scanning Post Data Displays
Constraint Definitions	Displacement.Stress,Etc	
Load Definition	Calculation	
Model Displays		

5. CONCLUSION

The development of a composite leaf spring having constant cross sectional area, where the stress level at any station in the leaf spring is considered constant due to the parabolic type of the thickness of the spring, has proved to be very effective.

The study demonstrated that composites can be used for leaf springs for light weight vehicles and meet the requirements, together with substantial weight savings. The 3-D modeling of composite leaf spring is done and analyzed using ANSYS.

A comparative study has been made between composite and steel leaf spring with respect to weight, cost and strength. From the results, it is observed 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 **Conclusion**; by comparison of FEM results of composite carbon fiber leaf with steel springs weight load, deflection, natural frequency & stress.

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