DESIGN AND FABRICATION OF FIBER COMPOSITE MONO LEAF SPRING FOR LIGHT VEHICLES

[1]B.NAGENDRA BABU , [2] GUDE LAKSHMAN RAO, [3] B.SIVA TEJA ,[4] B.VENKATESWARA NAIK, [5] K. NARESH KUMAR

1Assistant Professor, [2-5]UG Students
1Department of Mechanical Engineering,
[1-5] KKR&KSR INSTITUTE OF TECHNOLOGY&SCIENCES,GUNTUR,INDIA

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 with composite leaf spring with 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 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 composite leaf spring with E-glass/Epoxy composite materials is modeled and subjected to the same load as that of a steel spring. The composite leaf spring has been modeled by their consideration.

IndexTerms *- Leaf spring, E-glass/Epoxy. Natural fiber*

I. INTRODUCTION:

A leaf spring is a simple form of spring commonly used for the suspension in wheeled vehicles. Weight reduction can be achieved by designing new materials and sophisticated manufacturing processes. Due to increasing competition and innovation in recent decades, automobile industries show interestin replacing conventional steel leaf spring with fiber-reinforced composite leaf spring which has advantages such as higher strength to weight ratio, higher stiffness, high impact energy absorption, and lesser stresses. Objective of this mini project is to present a general study on the performance comparison of composite (e- glass epoxy fiber –reinforced polymer) leaf spring and conventional leaf spring

The conventional steel leaf spring and the composite leaf spring were analyzed under constant and variable load conditions using UTM and the results are compared .The conclusion of work is to minimize stress and deformation in E-Glass Epoxy composite leaf spring compared to steel leaf spring for automobile suspension system. For manufacturing the hand layup techniques are used with multi direction of fiber to get a maximum strength and minimum stress value with proper deflection.

Venkatshan.M.et.al. [1] has studied about the leaf springs are commonly used in suspension systems to absorb shocks and vibrations during loading and unloading in automobiles like light vehicles, heavy duty vehicles such as in trucks, buses and in rail systems. It carries various loads, brake torque, driving torque, various forces in addition to shock absorbing.

Khurmi.R.S.et.al. [2] has studied about the advantage of leaf spring over helical spring is that the ends of the spring may be guided along a definite path as it deflects to act as a structural member in addition to energy absorbing device. Also design procedure for conventional leaf spring is studied.

Ramakant.U.S.et.al. [3] has studied for selection of material should be with maximum strength and minimum modulus of elasticity in the longitudinal direction also forms with different directions of fiber to enhance the strengthening properties of that material for a leaf spring.

Lakshmi Narayana.V. [4] studied weight reduction of automobiles as it tends to the reduction of un-sprung weight of automobile. The elements whose weight is not impacted over the suspension spring are called the un-sprung elements of the automobile. This includes chassis, wheel assembly, axles, and part of the weight of suspension spring and shock absorbers. The leaf spring accounts for 10-20% 0f the un-sprung weight.

Gebremeskel .S.A and Patnaik.M.et.al. [5,6] has studied composite materials and made it is possible to reduce the weight of any machine element without any reduction of the load carrying capacity of that element. Because of composite material's high strength-to- weight ratio and high deflection compared with those of steel.

Basic Concept of composite leaf spring:

The automobile industry is showing increased interest in the replacement of steel spring with E-Glass/Epoxy fiber composite leaf spring due to high strength to weight ratio. Therefore; this project aims at comparative study of design parameters of a traditional steel leaf spring assembly and mono composite leaf spring. The aim of the present study is to conduct structural analysis on composite (E-Glass/Epoxy fiber–reinforced polymer) leaf spring and conventional leaf spring by hand lay-up method. The conventional steel leaf spring and the composite leaf spring were analyzed under Constant and Variable Load conditions using UTM test and the results are compared.

Design of composite leaf spring
Force calculation:

Average weight of four wheeler vehicle = 815 kg

Take, Factor of safety (F.O.S.) = 2

Gravitational force [g] = 9.81 m/

Total load in N = 815 × 9.81 × 2 = 16000 N Weight in single wheel = 16000/4 = 4000 N Max. stress and deflection:
Max. Stress = 473 MPa. Max. deflection = 105 mm. Straight length of leaf spring = 1072mm
Ratio of camber length to leaf span
C/L = 0.089
camber length = 1072 × 0.089 = 95.4mm ≈ 96

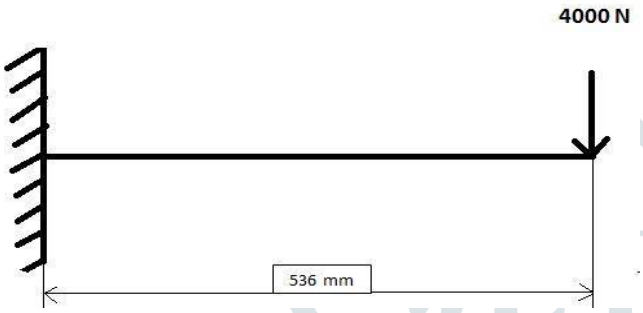


Fig. Leaf spring as cantilever beam

Composite material:

In general, a composite is a material mixture created by a synthetic/natural assembly of two or more physically and chemically distinct components. The first component is a selected filler or reinforcing agent (discontinuous phase) whilst the other component is a compatible matrix binder (continuous phase). These two components are combined in order to achieve specific characteristics and properties. Different types of fibers matrix and processing techniques are used for composite fabrication.

Fiber-Fibers are the principal constituents in a fiber reinforced composite material. They occupy the largest volume fraction in a composite laminate and share the major portion of the load acting on a composite structure. Proper selection of the fiber type, fiber volume fraction, fiber length, and fiber orientation is very important.

Glass fiber- Glass fibers are the most common of all reinforcing fibers for polymeric matrix composites (PMC). The principal advantages of glass fibers are low cost, high tensile strength, high chemical resistance, and excellent insulating properties.

Matrix- A matrix is a binder material that is used to hold fibers in position and transfer external loads to internal reinforcements. In natural fiber-reinforced polymer composites, both thermoset and thermoplastic matrices such as unsaturated polyesters, epoxies and phenolics, and polypropylenes, polyethylenes and elastomers, respectively, are widely used for composite applications. From above we selecting Epoxy resin for our project.

Fabrication Technique

It is the oldest molding method for making composite products. It requires no technical skill and no machinery. It is a low volume, labor intensive method suited especially for large components, such as boat hulls. A male and female half of the mould is commonly used in the hand lay-up process.

Manufacturing of composite leaf spring

There are following stages in fabrication of composite leaf spring

Preparation of mold:

The mold will have the shape of the product. In order to have a glossy or texture finish on the surface of the product, the mold surface also should have the respective finish. If the outer surface of the product to be smooth, the product is made inside a female mold. Likewise, if the inner side has to be smooth, the molding is done over a male mold. The mold should be free from defects, since the imprint of any defect will be formed on the product.

For preparation of mold we are using thin sheet metal of galvanized iron cut in the dimension of leaf spring that is 800*70 mm.

Conventional leaf spring

For giving required curvature shape we are using conventional leaf. To give proper adhesion of sheet metal double sided cello tube are stacked on the surface of leaf.


stacking of sheet metal on conventional leaf

Sheet metal is stacked on the conventional leaf and again for proper adhesion it is bonded by steel wires at both end.

Making of thickness

For making of thickness thermo coal strips of 12 mm height are used and fixed on the sheet by fevicoal and mold is ready to use.

Preparation of composite:

In the present investigation, a leaf spring made with E-Glass/Epoxy fiber material is considered which has the major constituent's

glass fiber and epoxy resin and made by hand layup method.

In above glasses 50 ml of resin and 50 ml of hardener is take and mixed with proportion of

Finally homogeneous mixture of resin is ready for usage.

Cutting of glass fiber material:


cutting of glass fiber

First marking is done on the as per required angle and cutting of fiber is carried out.

Stacking of extraction material

In order to obtain surface finish on the surface of the component of composite Perspex sheet is layered on the mold, then different layers of fibers and matrix are given. For easily remove of composite leaf spring cello tape is stacked on the whole mold cavity .

Hand Lay-up technique:

It is the oldest molding method for making composite products. It requires no technical skill and no machinery. It is a low volume, labor intensive method suited especially for large components, such as boat hulls. A male and female half of the mould is commonly used in the hand lay-up process. A typical structure of hand lay-up product being made is shown in below

Fiber orientation of 90 and 0 .Fiber orientation of 45 and -45

Curing of Composite:

Curing of composite leaf spring Finishing of leaf spring:

Testing of composite leaf spring:

Actual testing of the composite leaf spring is done with the help of universal testing machine. Here we are finding the deflection of the leaf spring and stress induced during loading condition. We get stress in compression 2.382 and deflection equal to 80 mm.

Testing on UTM

Comparison of FEA results for maximum stress induced in Steel and composite leaf spring :

Table :comparison for stress value for various loads

S. NO	Material	Laod In N	Stress In MPA	Deformation
1	Steel	1000	36.968	98.24
2	E-Glass/ epoxy	2000	17.50	57.47

Comparison of weight:

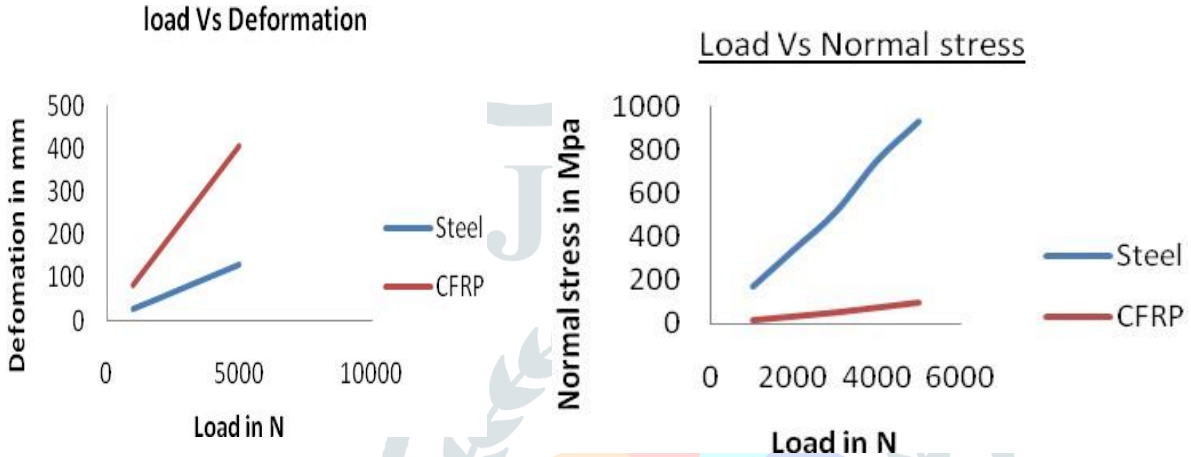
The total weight of composite leaf spring is 1.5Kg. The weight of a convectional steel spring assembly is around 3Kg. So, around 50% of weight reduction is achieved. Thus the objective of reducing the un sprung mass is achieved to a larger extent.

Comparison based on rigidity qualities:

The weight reduction of un sprung mass of an automobile will improve the riding quality. The suspension leaf contributes 10% - 20% of the un sprung mass. The weight of the composite leaf spring is 10 to 12 times less than steel leaf spring. Hence the riding comfort of an automobile is increased due to the replacement of the steel leaf spring by composite leaf spring. No one to the best of knowledge has worked but qualitatively on how much improvement in mileage/lit of passenger vehicle occurs and how much riding comfort improves. Only qualitative information is available on riding comfort of vehicle with respect to its un sprung mass. Steel spring is a multi-leaf spring and its inter-leaf fabrication reduces its riding quality. But composite leaf spring is a mono-leaf spring and more conductive to riding qualities.

Cost comparison:

The cost estimation of composite leaf spring provides a clear economic viability of the product in comparison to that of a convectional leaf spring. The conventional leaf spring assembly is available in the market for Rs 1000. By assuming a profit margin of 25% of the leaf spring, the cost of the leaf spring works out to be Rs 750. Hence it concerns that the cost of a composite leaf spring is equal to that of a convectional leaf spring even at a development stage. This shows that if mass production is achieved the cost can be reduced by 20% - 30% of the cost of a convectional leaf spring.



Comparison graph between two leaf springs: Graph of load Vs Deformation

Conclusion:

The composite leaf spring is designed according to constant cross-section area method. Different direction of fiber are gives a more strength as compared to normal direction. A comparative study has been made between composite and steel leaf springs with respect to stress, deflection, weight, riding quality, cost and strength. From the comparison, it was observed that the deflection in the composite is more but the bending stress induced in the E-Glass/epoxy composite leaf spring is less than the conventional steel leaf spring for the same load carrying capacity. Stress and deformation in E-Glass/epoxy composite leaf spring compared to steel leaf spring for automobile suspension system were observed that for the same cross- section the composite material is not suitable for heavy loads due to high deflection, for heavy loads the cross section of composite has to be changed.

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