Composite Leaf Spring- Review Paper

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Abstract— Automobile industry has shown increased interest in the replacement of steel spring with composite one because of high strength to weight ratio. Due to which 50% or more than that weight and cost reduction is achievable. The material of Carbon Fiber Reinforced Plastic (GFRP) is suitable for manufacturing of leaf spring. The strength of this composite depends on volume to weight ratio of reinforcement, L/D ratio of fiber, orientation angles etc. The proposed design finds to reduce the weight of vehicle as well useful to reduce the cost. It gives a high level of comfort. Therefore, analysis of the composite material becomes equally important to study the behavior of Composite Leaf Spring. The aim is to review the paper about fabrication and analysis of composite leaf spring.

Keywords: High Strength to Weight Ratio, Finite element analysis, Weight reduction, Optimum Cost.

I. INTRODUCTION

In order to conserve natural resources and economize energy, the weight reduction and optimum cost is the main focus of automobile manufacturers in the present. Composite materials play an important role in automotive as well as industrial applications. Weight reduction is achieved by the introduction of better material, manufacturing processes and design optimization. The suspension leaf spring is one of the products in which weight reduction is possible. As it accounts 10%-20% of the unsprung weight [1]. This achieves the vehicle with more fuel efficiency as well as improved ride qualities. As the composite materials have more elastic strain energy storage capacity and high strength to weight ratio as compared to steel, the composite material offer opportunities for substantial weight saving. The paper is focusing on the implementation of composite materials by replacing steel in conventional leaf springs of a suspension system. Composite materials have made it possible to reduce the weight of leaf spring without any reduction in load carrying capacity.

Composite materials are now used extensively in place of metal parts. It can find the application of composite materials in several automobile applications [2, 3]. The automobile-sector is showing an increased interest in the area of composite material-leaf springs due to their high strength to weight ratio [2]. Therefore analysis of composite material leaf springs has become essential in showing the comparative results with conventional leaf springs [4]. Dara Ashok, et al, In his work they give the information about design and structural analysis of composite leaf spring made of carbon fiber reinforced polymer (GFRP) [1]. Sachin Kr, et al, in the work a general study on the design, analysis and fabrication of composite leaf spring is done. They reviewed some papers on the use of alternate materials, effect of material on leaf spring performance and fatigue life prediction of leaf spring. They focus on the performance of epoxy carbon fiber reinforced materials used in leaf spring [2]. Vinkel Arora, et al, The paper is focused on determination of better eye end design of single leaf spring used in light motor vehicle [3]. The objective of the work is to carry out computer aided design and analysis of a conventional leaf spring, with experimental and computational design considerations and loading conditions using CATIA and ANSYS. M. M. Patunkar, et al, In his paper a comparison analysis of steel leaf spring is done with a virtual model of a composite leaf spring under the same static load condition. Deflection and stresses of steel leaf spring and composite leaf spring are to be analyzed [4]. M. Raghavedra, et al, The composite material offer opportunities for substantial weight saving but not always are cost-effective over their steel counter parts. From the results, it is observed that the laminated composite leaf spring is lighter and more economical than the conventional steel spring with similar design specifications [5]. M.Venkatesan and D. Helmen Devaraj, The paper gives design and experimental analysis of composite leaf spring made of carbon fiber reinforced polymer. The main objective is to compare the stiffness, load carrying capacity and weight of composite leaf spring with that of steel leaf spring. The dimension of an the light commercial vehicle is used. The design constraints are stresses and deflections. In which finite element analysis with full load on the 3-D model of composite multi leaf spring is done using ANSYS 10 and the analytical results are compared with experimental results. After studying the above paper, it is seen that the study in present topic will find new era in this sector.

II. PARAMETERS CONSIDERED

A. Material selection:

The material selection criteria are so much important in design of leaf spring. It is depends on the parameters such as High strength, Economy, Versatility & flexibility, Corrosion resistance, Weight advantages of material.

B. Proposed material for leaf spring:

The proposed material for the leaf spring is Composite material of Carbon Fiber Reinforced Plastic. The material offer following advantages over the other materials are: It offers high strength as compared to conventional materials of leaf spring. It is having lowest cost of manufacturing as compare to conventional. It has high corrosion resistance property as well as lower weight to strength ratio.

C. Properties of composite material:

The material Carbon / epoxy composite with 65% fiber volume is selected for Composite leaf spring. Carbon fibers are selected as they have low cost compared to either Carbon / Graphite fibers. It has high strength, high chemical resistance. But, the density is high compared to the other fibers.

Fibers – Carbon high quality fiber, which is used as a standard reinforcement and has good mechanical property requirements. Resins– Epoxy resin and solvent is used. Hardener–PVA which is a low viscosity polyamine is selected. The specimen testing is done according to ASTM standards.

Now, the material used is Carbon epoxy fibre whose properties are as follows:

1	Tensile modulus along X-direction (Ex)	34000 MPa
2	Tensile modulus along Y-direction (Ey)	6530 MPa
3	Tensile modulus along Z-direction (Ez)	6530 MPa
4	Ultimate Tensile strength of the material	900 MPa
5	Ultimate Compressive strength of the material	450 MPa
6	Poisson ratio along X-Y direction (NUxy)	0.217
7	Poisson ratio along Y-Z direction (NUyz)	0.366
8	Poisson ratio along Z-X direction (NUzx)	0.217
9	Mass density of the material (ρ)	2.6×10-6 kg/mm3

D. Design related theory:

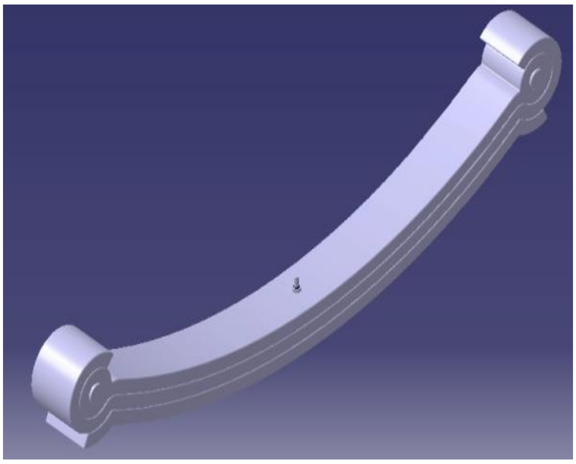
In this constant cross section design is considered cause of following reasons. In which both thickness and width are kept constant throughout the leaf spring. Due to which,

1. Capability for mass production and accommodation of continuous reinforcement of fibers.

2. Since the cross-section area is constant throughout the leaf spring, same quantity of reinforcement fiber and resin can be fed.

MODELING OF GFRP LEAF SPRING

The modeling of composite leaf spring is done with CAD software. CATIA V5 modeling software is used and virtual model of the multilayer composite leaf spring is done considering all dimensions and tolerances.



III.TYPES OF MANUFACTURING PROCESSES

- Pultrusion
- Filament winding
- Lamination type process
- Hand lay-up Technique

HAND LAY-UP TECHNIQUE

Hand layup technique is suitable for manufacturing of composite leaf spring with suitable effective properties. In this process a mould cavity made up with the help of green sand mould, after manufacturing cavity of suitable size optical gel coating of suitable thickness layer is made in the boundary of cavity then after this resin in liquid form is poured in that cavity and for getting require shape the consolidation roller rolls over the two layer of resin and dry reinforcement fabric layer of given thickness.

Normally the work is carried out in a female mould with a polished gel coat surface on the inside. Having acquired and set up the mould at a convenient working height in the workshop, the following procedure should be adopted:

1. Wash the mould carefully with warm water and soft soap to remove any old PVC release agent, dust, grease, finger marks, etc.

2. Dry the mould thoroughly.

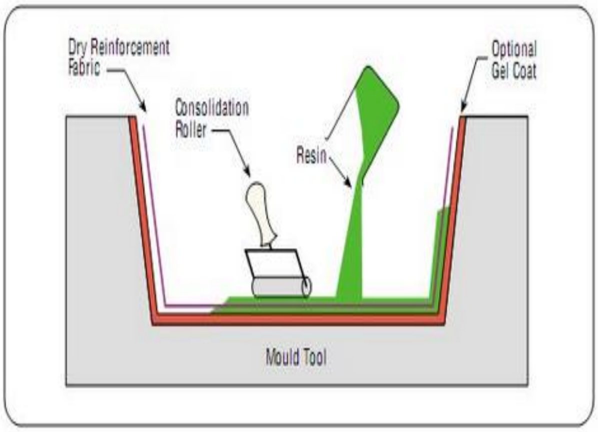
3. Check the mould surface for chips or blemishes. These should be repaired by filling with polyester filler and cutting back with wet/dry paper. The odd small chip can be temporarily repaired by filling with filler material.

4. If the mould surface is in good condition the mould release wax is now applied, with a circular motion, using a small piece of cloth. Three coats of wax are sufficient for a mould surface which has been previously 'broken in' but a new mould surface will require at least six applications. Each application is polished up to a high shine with a large piece of cheese cloth, after being left to harden for 15-20 minutes. Care must be taken to remove all streaks of wax. Be sure that the wax is polished and not removed by aggressive buffing. Failure to take care at this stage can result in stick up. Check application with manufacturer's instructions.

5. The fiber was cut to desired length, so that they can be deposited on mold layer- by layer during fabrication of composite leaf spring.

6. Prepare the solution of resin & Place the first layer of fiber chopped mat on mould followed by epoxy resin solution over mat.

7. Wait for 5-10 min. Repeat the procedure till the desired thickness was obtained. The duration of the process may take up to 25- 30 min. And finally remove the leaf spring from mould.[7]



IV.OPTIMUM VOLUME OF FIBER AND MATRIX IN COMPOSITE

Composite material may be either isotropic or anisotropic, which is determined by the structure of composites.

Isotropic material is a material, properties of which do not depend on a direction of measuring. anisotropic material is a material, properties of which along a particular axis or parallel to a particular plane are different from the properties measured along other directions.

Rules of Mixture is method of approach to approximate estimation of composite material properties, based on an assumption that a composite property is the volume weigh average of phases properties.

According to rule of mixtures properties of composite materials are estimated as follows:

a. Density
b. Modulus of elasticity
c. Shear modulus
d. Poisson's ratio
e. Tensile strength

a. Density
dc=dm*Vm+df*Vf
Where,
dc= Density of the composite
dm= Density of the matrix
df = Density of the fiber
Vm=Volume of fraction of the Matrix
Vf= Volume of fraction of the fiber

b. Modulus of elasticity
Modulus of Elasticity in longitudinal direction
Ecl=Em*Vm+Ef*Vf
Modulus of Elasticity in transverse direction
1/Ect=Vm/Em+Vf/Ef

c. Shear modulus
Gct=GfGm/(VfGm+VmGf)
Where
Gf=shear modulus of elasticity of fiber material
Gm=shear modulus of elasticity of matrix material

d. Poisson's ratio
μ12=Vfμf+Vmμm
Where
μf= Poisson's ratio of fiber material
μm= Poisson's ratio of matrix material

e. Tensile Strength

Tensile strength of long fiber rein forced composite in longitudinal direction

$\sigma c = \sigma m * Vm + \sigma f * Vf$

Where

σc= tensile strength of the composite

σm= tensile strength of the matrix

σf= tensile strength of the fiber

V.CONCLUSION

As reducing weight and increasing strength of products are high research demands in the world, composite materials are getting to be up to the mark of satisfying these demands. In this paper reducing weight of vehicles and increasing the strength of their spare parts is considered. As leaf spring contributes considerable amount of weight to the vehicle and needs to be strong enough, a single composite leaf spring is designed and it is shown that the resulting design and simulation stresses are much below the strength properties of the material satisfying the maximum stress failure criterion.

Carbon fibre/epoxy composite leaf spring can be suggested for replacing the steel leaf spring from stress and stiffness point of view.

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