

# A Review on Composite Made Leaf Spring for Automobiles

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**ABSTRACT:** Reducing weight while increasing or maintaining strength of products is getting to be highly important research issue in this modern world. Composite materials are one of the material families which are attracting researchers and being solutions of such issue. In this paper we describe design and analysis of polymer composite leaf spring. The objective is to compare the stresses, deformations and weight saving of composite leaf spring with that of steel leaf spring. The Automobile Industry has great interest for replacement of steel leaf spring with that of composite leaf spring, since the composite materials has high strength to weight ratio and good corrosion resistance. The material selected was glass fibre reinforced polymer (E-glass/epoxy) and is used against conventional steel. The design parameters were selected and analysed with the objective of minimizing weight of the composite leaf spring as compared to the steel leaf spring.

The leaf spring was modelled in solid works and the analysis was done using ANSYS 15.0 workbench. The fatigue life of both steel and composite leaf is compared using ANSYS software.

**KEYWORDS:** Stiffness, Composite Leaf Spring, E-Glass/Epoxy, ANSYS 15.0.

## I. INTRODUCTION

A leaf spring is a simple form of spring, commonly used for the suspension in heavy vehicles. It is also one of the oldest forms of suspension system. The advantage of leaf spring over helical spring is that the end of the springs may be guided along a definite path. The centre of the arc provides location for the axle, while tie holes are provided at either end for attaching to the vehicle body. For very heavy vehicles, a leaf spring can be made from several leaves stacked on top of each other in several layer with progressively shorter leaves. Leaf springs can to some extent damping as well as springing functions. A leaf spring can either be attached directly to the frame at both ends or attached directly at one end, usually the front, with the other end attached through a shackle, a short swinging arm. The shackle takes up the tendency of the leaf spring to elongate when compressed and thus makes for softer springing actions.

The spring consists of a number of leaves called blades. The blades are varying in length. The blades are us usually given an initial curvature or cambered so that they will tend to straighten under the load. The lengthiest blade has eyes on its ends. This blade is called main or master leaf, the remaining blades are called graduated leaves. All the blades are bound together by means of steel straps. The spring is mounted on the axle of the vehicle. The entire vehicle load is rests on the leaf spring

The idea of using E-Glass epoxy instead of carbon steel was obtained from the paper by Ghodake A. P., Patil K.N. [1]. The Experimental characterization of the mechanical properties of E-glass/Epoxy & E-glass/Polyester composite was obtained from the journal by EsmaelAdema, Er. MukeshDidwaniab [2]. The static analysis and the various loads acting on the spring were obtained from the journal paper by Asst. Prof. G. HarinathGowd [3]. A finite element approach for analysis of leaf spring was obtained from the journal by Kumarkrishna and Aggarwal M. [4]. All the subsequent papers relating to this topic were pointed to the same direction in terms of improving the context, which were used in analysing the various working conditions.

The work in this review paper is divided into four different sections. Section 1 is about introduction to leaf spring, section 2 deals with the different loads acting on the leaf spring, section 3 deals with the methodology used for making the polymer composite mono leaf spring. Section 4 deals with the different types of test done for the evaluation of the mono leaf spring.

## II. VERTICAL LOADS

When the rear wheel comes across a bump or pit on the road, it is subjected to vertical forces, tensile or compressive depending upon the nature of the road irregularity. These are absorbed by the elastic compression, shear, bending or twisting of the spring. The mode of spring resistance depends upon the type and material of the spring used. Further when the front wheel strikes a bump it starts vibrating. These vibrations die down exponentially due to damping present in the system. The rear wheel however, reaches the same bump after certain time depending on the wheel base and the speed of the vehicle. Of course, when rear wheel reaches the bump, it experiences similar vibrations as experienced by the front wheel some time ago. It is seen that to reduce pitching tendency of the vehicle, the frequency of the front springing system be less than that of the rear springing system.

### Rolling

The centre of gravity of the vehicle is considerably above the ground. Due to this reason, while taking a turn, the centrifugal force acts outwards on the C.G of the vehicle, while the road resistance acts inward at the wheels. This gives rise to a couple turning the vehicle about a longitudinal axis. This is called rolling.

### Brake-dip

On braking, the nose of the vehicle has a tendency to be lowered or to dip. This depends upon the position of centre of gravity relative to the ground, the wheelbase, and other suspension. In the characteristics the same way, torque loads during acceleration end the front of the vehicle to be lifted. These forces on account of braking and driving are carried directly by deflecting the springs, by wishbone arms.

### Side thrust

Centrifugal force during cornering, cross-winds, cambering of the road etc., cause a side-thrust to be applied to the vehicle, such forces are usually absorbed by the rigidity of the leaf springs.

### Unsprung weight:

Un-sprung weight is the weight of vehicle components between the suspension and then road surface. This includes rear axle assembly, steering knuckle, and front axle in case of rear drive rigid suspension, wheels, tires and brakes. The sprung weight i.e. the weight supported by the vehicle suspension system, includes the frame, body, engine, and the entire transmission system.

When the wheels strike against a bump, they vibrate along with other unsprung parts which store the energy of the vibrations and then further transmit it to the sprung parts via the springs. Thus it is seen that greater the weight of the unsprung parts, greater will be the energy stored due to vibrations and consequently greater shocks.

### Fatigue

The term fatigue of materials and structural components means damage and damage due to cyclic, repeatedly applied stresses. In material science, fatigue is the progressive, localized, and permanent structural damage that occurs when a material is subjected to cyclic or fluctuating strains at nominal stresses that have maximum values less than the static yield strength of the material. The resulting stress may be below the ultimate tensile stress, or even the yield stress of the material, yet still cause catastrophic failure.

### Materials for leaf spring

The material used for leaf springs is usually a plain carbon steel having 0.90 to 1.0% carbon. The leaves are heat treated after the forming process. The heat treatment of spring steel products has greater strength and therefore greater load capacity, greater range of deflection and better fatigue properties

### Carbon/graphite fibers

Their advantages include high specific strength and modulus, low coefficient of thermal expansion and high fatigue strength. Graphite, when used alone has low impact resistance. Its drawbacks include high cost, low impact resistance and high electrical conductivity.

### Carbon steel

Carbon steel, or plain-carbon steel, is a metal alloy. It is a combination of two elements, iron and carbon. Other elements are present in quantities too small to affect its properties. The only other elements allowed in plain-carbon steel are: manganese (1.65% max), silicon (0.60% max), and copper (0.60% max). Steel with low carbon content has the same properties as iron, soft but easily formed. As carbon content rises the metal becomes harder and stronger but

less ductile and more difficult to weld.

### **E glass**

Glass fibre has roughly comparable mechanical properties to other fibres such as polymers and carbon fibre. Although not as strong or as rigid as carbon fibre, it is much cheaper and significantly less brittle when used in composites. Glass fibres are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight Fibre Reinforced Polymer (FRP) composite material called Glass Reinforced Plastic (GRP), also popularly known as "E-glass". This structural material product contains little or no air or gas, is denser, and is a much poorer thermal insulator than is glass wool.

## **III. DISCUSSION**

Leaf springs are mainly used in suspension systems to absorb shock loads in automobiles like light motor vehicles, heavy duty trucks and in rail systems. It carries lateral loads, brake torque, driving torque in addition to shock absorbing. 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. According to the studies made a material with maximum strength and minimum modulus of elasticity in the longitudinal direction is the most suitable material for a leaf spring. 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 unsprung weight. This achieves the vehicle with more fuel efficiency and improved riding qualities.

The introduction of composite materials made it possible to reduce the weight of leaf spring without any reduction on load carrying capacity and stiffness, by its high elastic strain energy storage capacity and high strength-to-weight ratio compared with those of steel. The elements whose weight is not transmitted to the suspension spring are called the unsprung elements of the automobile. This includes wheel assembly, axles, and part of the weight of suspension spring and shock absorbers. The leaf spring accounts for 10-20% of the un-sprung weight. FRP springs also have excellent fatigue resistance and durability. But the weight reduction of the leaf spring is achieved not only by material replacement but also by design optimization.

Weight reduction has been the main focus of automotive manufacturers in the present scenario. The replacement of steel with optimally designed composite leaf spring can provide up to 85% weight reduction. Moreover the composite leaf spring has lower stresses compared to steel spring. All these will result in fuel saving which will make countries energy independent because fuel saved is fuel produced.

### **Methodology**

#### **Preparation of polymer composite**

The glass/Epoxy composite is fabricated using simple hand layup technique. The procedure consists of placing the glass fibres, layer by layer and applying liquid epoxy mixed with hardener on the glass fibres in order to form a solid network cross-linked polymer. The layup assembly is pressed with the help of roller so that excess air between the layers is expelled out. The laminate is cured at ambient conditions for a period of about 24hrs.

#### **Making of the leaf spring**

The making of leaf spring process involves building up a component on the fibreglass mould. The mould is a negative image of the leaf spring to be made, so the fibreglass will be applied inside the mould, rather than around it. As in the mould-making process, release agent is first applied to the mould. Layers of fibreglass are then applied, using the same procedure as before. Once completed and cured, the component is separated from the mould using wedges, compressed air or both.

#### **Curing**

Curing is a term in polymer chemistry and process engineering that refers to the toughening or hardening of a polymer material by cross-linking of polymer chains, brought about by electron beams, heat or chemical additives. Tests are done to ensure that the designed mono leaf spring is able to withstand the loads acting on it for this the actual load acting on it is given as the input during the various test conducted and these inputs are also given in ANSYS 15.0 for ensuring that the output results are correct.

#### **Test to be conducted**

**Tensile testing:** It is a fundamental materials science test in which a sample is subjected to a controlled tension until failure.

**Torsion test:** It is to determine the behaviour of a material or test sample exhibits when twisted or under torsional forces as a result of applied moments that cause shear stress about the axis.

**Scanning electron microscope (sem):** It provides detailed high resolution images of the sample by emitting a focussed electron beam across the surface and detecting secondary or backscattered electron signal. An Energy Dispersive X-Ray Analyser (EDX or EDA) is also used to provide elemental identification and quantitative compositional information.

**Hardness:** It is a measure of how resistant solid matter is to various kinds of permanent shape change when a compressive force is applied. Some materials are harder than others. Macroscopic hardness is generally characterized by strong intermolecular bonds, but the behaviour of solid materials under force is complex; therefore, there are different measurements of hardness: scratch hardness, indentation hardness, and rebound hardness.

**Fourier transforms infrared spectroscopy:** It is a technique which is used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas. An FTIR spectrometer simultaneously collects high spectral resolution data over a wide spectral range. This confers a significant advantage over a dispersive spectrometer which measures intensity over a narrow range of wavelengths at a time.

**X-ray crystallography:** It is a technique used for determining the atomic and molecular structure of a crystal, in which the crystalline atoms cause a beam of incident X-rays to diffract into many specific directions. By measuring the angles and intensities of these diffracted beams, a crystallographer can produce a three-dimensional picture of the density of electrons within the crystal. From this electron density, the mean positions of the atoms in the crystal can be determined, as well as their chemical bonds, their disorder, and various other information.

**Thermogravimetric analysis or thermal gravimetric analysis (tga):** It is a method of thermal analysis in which changes in physical and chemical properties of materials are measured as a function of increasing temperature, or as a function of time TGA can provide information about physical phenomena, such as second-order phase transitions, including vaporization, sublimation, absorption, adsorption, and desorption. Likewise, TGA can provide information about chemical phenomena including chemisorptions, desolvation, decomposition, and solid-gas reactions (e.g., oxidation or reduction).

**Fatigue test:** A specified mean load and an alternating load are applied to a specimen and the number of cycles required to produce failure (fatigue life) is recorded. Generally, the test is repeated with identical specimens and various fluctuating loads. Loads may be applied axially, in torsion, or in flexure.

**Bending test:** The bend test is a simple and inexpensive qualitative test that can be used to evaluate both the ductility and soundness of a material. It is often used as a quality control test for butt-welded joints, having the advantage of simplicity of both test piece and equipment.

### Software analysis

The ANSYS structural analysis software suite enables you to solve complex structural engineering problems and make better, faster design decisions. With finite element analysis (FEA) tools, you can customize and automate your simulations, and parameterize them to analyse multiple design scenarios. ANSYS Structural Mechanics software easily connects to other physics analysis tools, providing even greater realism in predicting the behaviour and performance of complex products. ANSYS FEA software is used throughout industry to enable engineers to optimize their product designs.

## IV. CONCLUSION

The existing carbon steel material can be replaced with the composites without compromising life, reliability and performance of leaf spring. In this work, selection of different composite material based on requirement of properties of leaf spring is made. E-glass epoxy is better than using carbon steel as though stresses are little bit higher than carbon steel, E-glass epoxy is having good yield strength value and also epoxy material components are easy to manufacture and this having very low weight while comparing with traditional materials. Riding comfort and performance is improved due to reduction in unsprung mass of the vehicle.

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