

Design and Analysis of Composite Leaf Spring Made Of Nylon 6/6 GF-30 (30% Glass Fiber Reinforced)

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ABSTRACT: The paper describes the replacement of steel spring with composite leaf spring Nylon 6/6 GF -30 (30% Glass fiber Reinforced). The aim of this paper is to be achieve the weight reduction by introducing the composite leaf spring using nylon 6/6 GF-30/Epoxy combination. material. In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturer in the present scenario. The design and analysis of composite leaf spring and compare leaf spring by CREO and ANSYS software. The designed composite leaf spring has given result of lower stresses, higher natural frequency, and higher weight reduction.

KEYWORDS: Leaf spring, Composites, nylon 6/6.

I. BACKGROUND

In the Automobile sector, to optimize the utilization of energy, weight reduction became one of the main focuses of automobile manufacturers. Weight reduction can be achieved by the introduction of better materials. Leaf springs are mainly used in suspension systems to absorb shock loads in automobiles like light motor vehicles, heavy duty trucks and also in rail systems. They carry lateral loads, brake torque, driving torque in addition to shock absorbing. Leaf springs are having an advantage that the ends of the spring may be guided along a definite path as it deflects. The use of composite materials for suspension leaf spring reduces the weight of conventional multi leaf steel leaf spring by nearly 75%. This achieves the vehicle with more fuel efficiency and improved riding qualities.

For more compliant suspension system (i.e. energy storage capability), the leaf spring should absorb the vertical vibrations and impacts due to road irregularities by means of variations in the spring deflection so that the potential Energy is stored in spring as strain energy and then released slowly. A material with maximum strength and minimum modulus of elasticity in the longitudinal direction is the most suitable material for a leaf spring. 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. The composite materials have more elastic strain energy storage capacity, excellent corrosion resistance, high strength to weight ratio as compared with those of steel.

Fatigue failure is the predominant mode of in-service failure of many automobile components. This is due to the fact that the automobile components are subjected to variety of fatigue loads like shocks caused due to road irregularities traced by the road wheels, the sudden loads due to the wheel traveling over the bumps etc. The leaf springs are more affected due to fatigue loads, as they are a part of the unstrung mass of the automobile. The fatigue behavior of Nylon6/6 GF-30 (30%Glass fiber Reinforced) Composite leaf spring has been studied.



In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturer 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 automobile as it accounts for ten to twenty percent of the unstrung weight. This helps in achieving the vehicle with improved riding qualities. It is well known that 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 introduction of composite materials was made it possible to reduce the weight of the 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 to those of steel.

II. LITERATURE REVIEW

- *Saurabh Singh, (2012) "Optimization of design of helical coil suspension system by combination of conventional steel and composite material in regular vehicle".* This paper demonstrates the feasibility of adopting composite material for design of helical coil suspension system. This is the combination of steel and composite material that is used the replacement of conventional steel. The composite material used in this analysis is Glass fiber/Epoxy.
- *T.S.Manjunatha, (2012) "Manufacturing and experimentation of composite helical spring for automotive suspensions".* This paper deals with fiber reinforced plastics in springs. Three different types of springs were manufactured using Glass, Carbon, Glass/Carbon fiber in +45 orientation. Stresses acting on the composite spring were less compared to steel spring.
- *V Jadhav Mahesh and B Zoman Digambar, (2012) "Performance analysis of two mono leaf spring used for Maruthi 800 vehicles".* In this paper we look on the suitability of composite leaf spring on vehicles and their advantages. These are same efforts have been made to reduce the cost of composite leaf spring to that of steel leaf spring. This paper shows the displacement of composite material may lead weight reduction and improve the mechanical properties of the leaf spring.
- *R Lalitha Narayana, et al., (2013) "Analysis of natural fiber composite leaf spring".* This paper shows that the leaf spring is made on the natural fiber material. The natural fiber material such as Jute is used and they good material

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properties as well as less weight.

- *K Vishwanathan and H Raghavandera Rao, (2013) "Optimization of heavy vehicle suspension system using composites"*. This paper deals with the replacement of composite material for a leaf spring in the heavy vehicle. Here Glass & Aramid fibers are used.
- *B Raghu Kumar, et al., (2012) "Static analysis of mono leaf spring with composite materials"*, Here the paper shows varies composite material that used in the leaf spring such as Graphite/Epoxy, Boron/ Aluminum , Carbon fiber/Epoxy & Kevlar fiber/ Epoxy. But Kevlar fiber/ Epoxy is most efficient then the other composite materials.
- *A C Baviskar, et al., (2013) "Design and analysis of a leaf spring for automobile suspension system"*. The paper represent a general study on the design analysis of leaf spring this paper also use the glass fiber to replace the metal in the leaf spring.

III. OBJECTIVES

The objectives of the composite leaf spring is as follows,

- To reduce the weight of the leaf spring
- To replace the traditional material of the leaf spring.
- To increase the load withstands capacity of the leaf spring.
- To increase the mechanical properties.
- To bring corrosion resistance in the leaf spring material.
- To improve the life of the leaf spring.

IV. PROBLEM DEFINITION

The problem definition from the steel leaf spring as follows,

- The steel leaf spring will not withstand the load above 4.25kN.
- Weight of the steel leaf spring is high.
- Cost of the steel leaf spring is high when compared to the composite leaf spring.
- It is generally corrosive in nature.

V. COMPOSITE MATERIAL

Definition:

Composite material is a material is composed of two or more distinct phases (matrix phase and dispersed phase) having bulk properties significantly different from those of any of constituents.

The composite materials has been classified into two types they are,

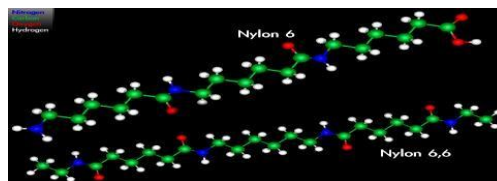
- Artificial Composite materials
- Natural Composite materials

Artificial Composite materials:

A Composite Material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. In contrast to metallic alloys, each material retains its separate chemical, physical and mechanical properties. The two constituents are reinforcement and a matrix. The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part.

NYLONS(Polyamides):

Polyamides(PA), also known as nylons, are the products of condensation reaction between an amine and an organic acid. There are number of common polyamides. They are usually designated as nylon 6, nylon 6/6, nylon 6/10, nylon 6/12, nylon 12. These suffixes refer to the number of carbon atoms in each of the reacting substance involved in the condensation polymerization process. Nylon with a slash(/) between numbers are copolymers; for example, nylon 6/12 is a copolymer of nylon 6 and nylon 12.



3-D structure of Nylon 6/6

Characteristics of nylons:

- They are crystalline thermoplastics with good mechanical properties.
- They are very strong and tough.
- They possess good abrasion resistance.
- They are flexible and have high impact strengths.

Glass Fiber:

Glass fibers are the most common of all reinforcing fibers for polymer matrix composite. The principal advantages are low cost, high tensile strength, high chemical strength and insulating properties. The disadvantages are low tensile modulus, relatively high specific gravity, sensitivity to abrasion with handling which frequently decreases tensile strength, relatively low fatigue resistance and high hardness. E (Electrical) and S (high content of silica) are commonly used. C (corrosion), D (Dielectrically), A (Appearance), R (structural reinforcement) are the other types.



Epoxies: The advantages are high mechanical strength and good adherence to metals and glasses; drawbacks are high cost and difficulty in processing.

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NYLON 6/6 GF-30 (30% Glass Fiber reinforced):

All NYLON 6/6 GF-30 (30% Glass Fiber reinforced) have mechanical strength and superior resistance to wear and organic chemicals. Nylon 6/6 GF-30 has more than double the strength and stiffness of reinforced nylon and heat deflection temperature which approaches its melting point.

Nylon 6/6 is a 30% glass fiber reinforced Nylon 6/6 material whose important properties include high tensile and flexile strength, stiffness, excellent heat deflection temperature and superior abrasion and wear resistance.

DESIGN:

Specifications of the existing leaf spring

S.No.	Specifications	Value
1.	Total Length of the spring (Eye to Eye)	950mm
2.	Free Camber (At no load condition)	110mm
3.	No. of leaves	3nos.
4.	Thickness of leaf	13mm
5.	Width of leaf spring	50mm
6.	Maximum Load given on spring	4250N
7.	Young's Modulus of the spring	2.1x10 ⁵ N/mm ²
8.	Weight of the leaf spring	23 kg

Design Calculations

Table 5.2 Specifications of the composite leaf spring

Material	Length (mm)	Width (mm)	Thickness (mm)	Chamber height (mm)	Radius of the arc (mm)	Weight (Kg)
Composite	950	50	40	110	1080.5	3.2

As we consider the thickness of the composite leaf spring as a influencing parameter. So, we assume the thickness value as 40mm.

The other design value that listed above (such as length, width, chamber height, radius of the arc) for the composite leaf spring is taken from the existing steel leaf spring. But after the testing has been done we had find out the apt thickness for composite leaf spring by the following calculations that had been found out.

Formula used:

Bending stress (Deflection (y)

$$b) = 6PL/nbt^2 = 6PL^3/Enbt^3$$

$$y = 6PL^3/Enbt^3$$

$$92.9 = (6 \times 2.125 \times 10^3 \times 475^3) / (0.34 \times 10^5 \times 1 \times 50 \times t^3)$$

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$$t = 20.52\text{mm}$$

$$\text{Bending stress } (\sigma_b) = 6PL/nbt^2$$

$$= (6 \times 2.125 \times 10^3 \times 475) / (1 \times 50 \times 20.52^2)$$

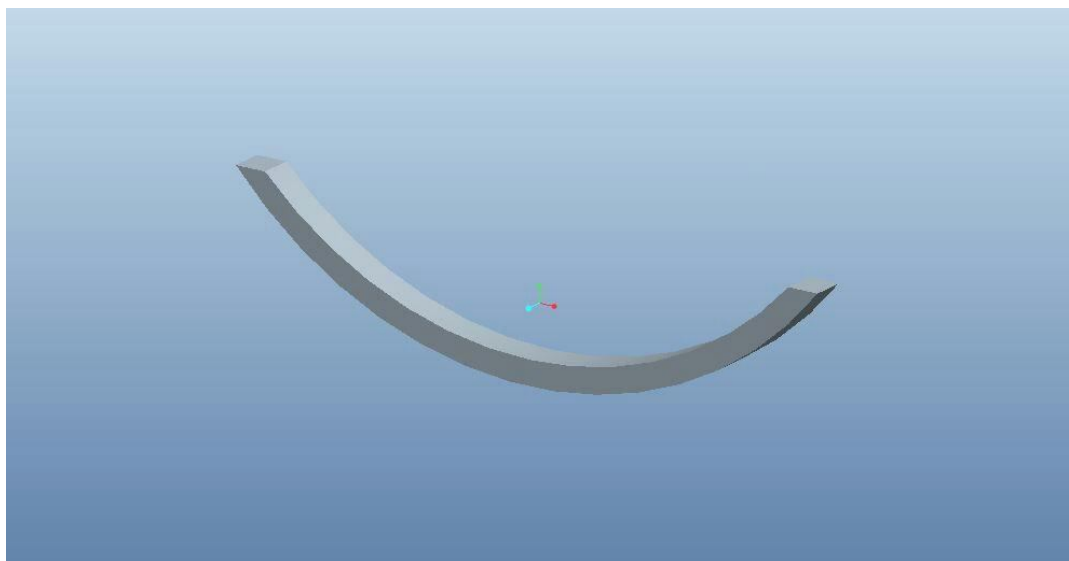
$$\sigma_b = 287.65 \text{ N/mm}^2$$

Thus, we had found out the thickness of the composite leaf spring.

Table 5.3 Dimensions of the composite leaf spring

Material	Length (mm)	Width (mm)	Thickness (mm)	Camber height (mm)	Radius of the arc (mm)	Weight (Kg)
Composite	950	50	20.52	110	1080.5	3.2

Thus after this calculation, we had found the optimum thickness of the leaf spring and the bending stress is also less when compared to the previous dimensions.

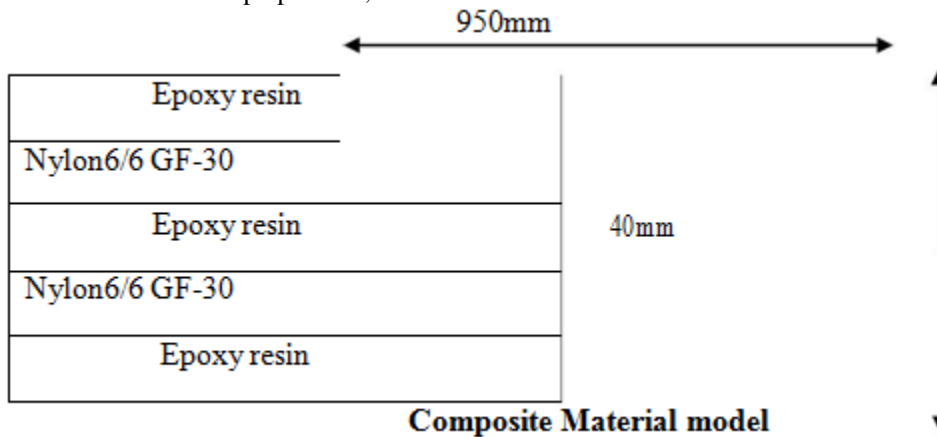


3-D view of the Master leaf

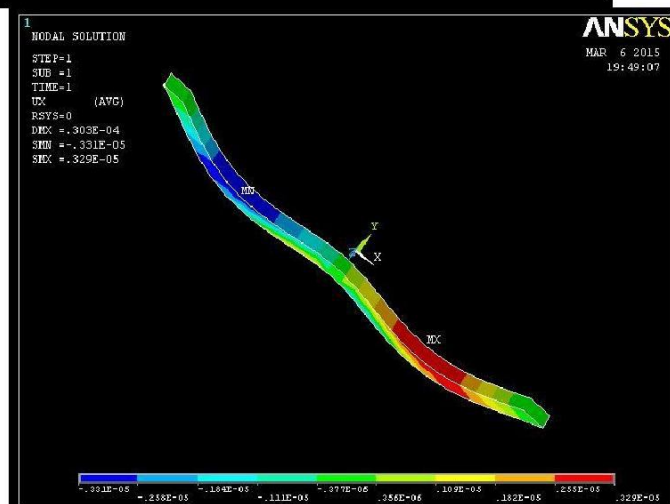
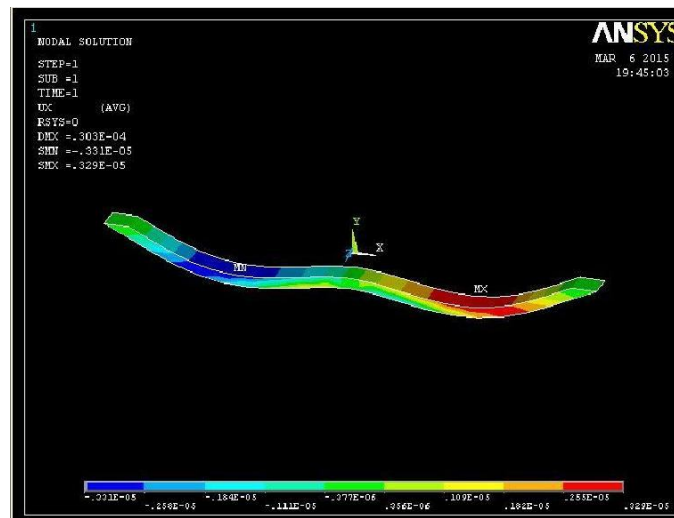
The above figure shows the three dimensional view of the composite leaf spring. The isometric view has been shown using the CREO software.

IV. IDEALOGY FOR PREPARATION

Steps to be followed while preparation, model shown below:



ANALAYSIS:



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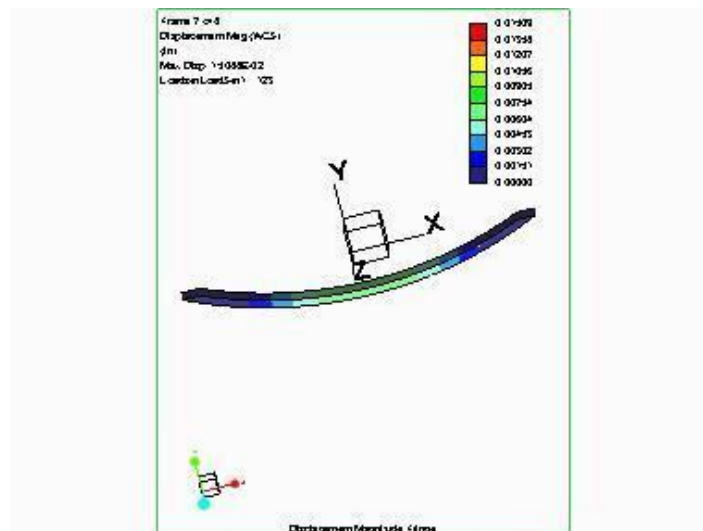
The above ANSYS result show the deflection report of composite leaf spring.

creo™ simulate



Results Report

displacement_fringe



displacement_fringe

For load 16kN

$$\begin{aligned} \text{Bending stress } (\sigma_b) &= 6PL/nbt^2 \\ &= (6 \times 8 \times 10^3 \times 475) / (1 \times 50 \times 40^3) \\ \sigma_b &= 285 \text{ N/mm}^2 \\ \text{Deflection (y)} &= 6PL^3/Enbt^3 \\ &= (6 \times 8 \times 10^3 \times 475^3) / (0.34 \times 10^5 \times 50 \times 40^3) \\ y &= 47.28 \text{ mm} \\ \text{Strain (e)} &= \text{Stress} / \text{Young modulus (E)} \\ &= 285 / 0.34 \times 10^5 \\ e &= 8.38 \times 10^{-3} \end{aligned}$$

For load 17.5kN (breaking point)

$$\begin{aligned} \text{Bending stress } (\sigma_b) &= 6PL/nbt^2 \\ &= (6 \times 8.75 \times 10^3 \times 475) / (1 \times 50 \times 40^3) \\ \sigma_b &= 311.71 \text{ N/mm}^2 \\ \text{Deflection (y)} &= 6PL^3/Enbt^3 \\ &= (6 \times 8.75 \times 10^3 \times 475^3) / (0.34 \times 10^5 \times 50 \times 40^3) \\ y &= 51.71 \text{ mm} \\ \text{Strain (e)} &= \text{Stress} / \text{Young modulus (E)} \\ &= 311.71 / 0.34 \times 10^5 \\ e &= 9.167 \times 10^{-3} \end{aligned}$$

VI. CONCLUSION

The above CREO Software stimulate report give displacement fringe for max load of 17.5KN. ANAYS report shows Deflection of composite leaf spring is less as compared to steel leaf spring with the same loading condition. The results have been made numerically using the standard formulas and ANSYS software. Using ANSYS software, deflection, stress and strain values has been found and compared with the experimental results and they are compared.

The study demonstrate the composites leaf spring should in light weight vehicles because of weight reduction. A comparative study has been made between composite and steel leaf spring with respect to weight and their mechanical properties. 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.

FUTUROLOGY: In future, automobile industry may prefer the above combination of composite leaf spr ing for light weight vehicles because of weight reduction and good riding qualities.