Volume : 2 | Issue : 3 | March 2013 ISSN - 2250-1991

Research Paper Engineering

A Review on Design and Analysis of Long Fiber Reinforced Thermoplastic Leaf spring

* D. K. Damor ** K. D. Kothari

* P.G Student, School of Engineering, RK University, Rajkot, Gujarat, India

** Associate Professor & Head, School of Engineering, RK University, Rajkot, Gujarat, India.

ABSTRACT

This project describes design and experimental analysis of composite leaf spring made of long glass fiber reinforced thermoplastic. 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 Long glass fiber reinforced thermoplastic (LFRT) unidirectional laminates. The design parameters were selected and analyzed with the objective of minimizing weight of the composite leaf spring as compared to the steel leaf spring. The solid model of the leaf spring was made in Pro-E 5.0 and the analysis was done using ANSYS 13.0.

Keywords : Composite materials, leaf spring, long fiber reinforced thermoplastic.

INTRODUCTION

Multi leaf spring carries lateral loads, brake torque, driving torque in addition to shock absorbing. Advantages of leaf spring over helical spring are that the ends of the springs are guided along a definite path and it is act as a structural member. It is well known that springs, are designed to absorb and store energy and then release it slowly. Ability to store and absorb more amount of strain energy ensures the comfortable suspension system. Hence, the strain energy of the material becomes a major factor in designing the springs. The relationship of the specific strain energy can be expressed as

$$U = \frac{\sigma^2}{2\rho E}$$

Where σ is the strength, ρ is the mass density and E is the Young's modulus of the spring material. It can easily understand that material having lower modulus and density will have greater specific strain energy capacity. It helps in achieving the vehicle with improved riding qualities. In composite materials, GFRP (Glass Fiber Reinforced Polymer) have chosen as spring material. Because it is 1.5-2 times stronger than the steel armature and high strength to weight ratio. It weighs 3.5 – 4 times less than the steel armature.

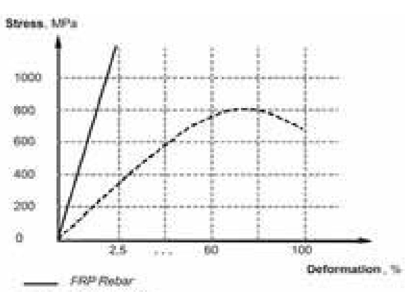

Figure 1: Stress strain curves for the composites and conventional steel [1]

Hence, Automobile sector is showing an increased interest in the area of composite material leaf springs. The stress strain curves for the composites and conventional steel shown in the below figure-1 [1].

Leaf spring originally called laminated or carriage spring, a leaf spring is a simple form of spring, commonly used for the suspension in wheeled vehicles. It is also one of the oldest forms of springing, dating back to medieval times. Sometimes referred to as a semi-elliptical spring or cart spring, it takes the form of a slender arc shaped length of spring steel of rectangular cross-section. The centre of the arc provides location for the axle, while tie holes called eyes are provided at either end for attaching to the vehicle body 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 springiness [2].

LITERATURE SURVEY

Dr. M.L Aggarwal & Vinkel Arora (2011) simulated a leaf spring model. An experimental leaf spring model was verified by using a leaf spring test rig that can measure vertical static deflection of leaf spring under static loading condition. A static load of 35KN (Full Load) and17.5KN (Half load) is applied by a universal testing machine and the corresponding deflection and stress values are observed. When the leaf spring is fully /half loaded, a variation of 1.17% in deflection is observed among the Experimental & CAE. At the same time bending stress for fully loaded, is increased by 12.30 % in CAE analysis as compared with experimental and for half loaded bending stress is increased by 12.02 %. This may be observed because the actual material is 65Si7 but for CAE analysis Structural steel is used.

Figure 2: Testing machine for leaf spring [5]

Gulur Siddaramanna Shiva Shankar, et al. (2006), in this paper the leaf spring performance is compared with steel spring experimentally as well as by FEA. The author found their adhesively bonded and joint and hands the performance of composite leaf spring in composite with bolded joint as stress constraints at holes are absorb in bolted joints over view of results for load deflection and stresses indicated that composite leaf spring which is 8.7 time lighter in weight can carry more static load with more deflection and less maximum stresses. Even in between the three type of composite leaf spring performance of E-glass/Epoxy was found based then other in harmonic analysis, the natural frequency of composite leaf spring is higher than that of the steel leaf spring and is far enough from the road frequency to avoid the reducing [7].

Table-1
Comparisons of Deflections and Bending Stresses [7]

		FEA	Expt.
Maximum Deflection	Integral eye	94	101
	Bonded joint	93	104
Maximum Banding stress	Integral eye	460	500
	Bonded joint	466	520

Table 2
Composite Results of Load, Deflection and Stresses [7]

Material	Load (N)	Maxi. Deflection (MPa)		Maxi. Stress (MPa)	
		FEA	Expt.	FEA	Expt
Steel	3980	90	107.5	511	503.3
E-Glass	4250	94	105.0	466	473
Graphite Epoxy	-	68	-	422	-
Carbon Epoxy	-	62	-	413	-

Table 3
Natural frequencies of composite Leaf Spring [7]

Modes	1	2	3	4	5
Frequency (Hz)	33	135	192	288.5	368.7

Kumar Krishan, Aggarwal M. L. (2012), in this paper the FE model of the leaf spring has been generated in CATIA V5 R17 and imported in ANSYS-11, which are most popular CAE tools. The FE analysis of the leaf spring has been performed by discretization of the model in infinite nodes and elements and refining them under defined boundary condition. A comparison of both i.e. experimental and FEA results have been done to conclude [8].

Rajendran & S. Vijayarangan (2001), this paper presents an artificial genetics approach for the design optimization of composite leaf spring. The design variable (thickness and width) of steel and composite leaf springs are optimized by making use of GA (Genetic Algorithm). Optimization using GA has contributed to a reduction of 8% of the steel spring weight and 23.4% of the composite spring weight [9].

CONCLUSION

From the above literature survey it may be concluded that using the composites material in automotive suspension leaf spring, reduce weight, increase the strength and stiffness therefore increase the performance of the automotive. The study demonstrated that composites can be used for leaf springs for light weight vehicles and meet the requirements, together with substantial weight savings. A comparative study has been made between composite and steel leaf spring with respect to weight, cost and strength. From the literature survey results, it is observed that the composite leaf spring is lighter and more economical than the conventional steel spring with similar design specifications. Better design of leaf spring will reduce the fuel consumption and increase the efficiency.

ACKNOWLEDGEMENT

We gratefully acknowledge Mechanical engineering department of RK University for technical support and providing the research facilities.

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