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MODAL ANALYSIS OF AUTOMOBILE LEAF SPRINGS

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ABSTRACT

The automobile industry has shown increased interest in the replacement of steel spring with fiber glass composite leaf spring due to high strength to weight ratio. This work deals with the replacement of conventional steel leaf spring with a Mono Composite leaf spring using E-Glass/Epoxy. 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.

KEYWORDS: Automobile Leaf Springs

INTRODUCTION

The automotive industry is exploring composite material technology for structural components construction in order to obtain the reduction of weight without decrease in vehicle quality and reliability. To conserve the natural resources and economize energy, weight reduction has been the main focus of automobile manufacturer in the present scenario. Actually, there is almost a direct proportionality between the weight of the vehicle and its fuel consumption, particularly in city driving. The advanced composite materials such as Graphite, Carbon, Kevlar and Glass with suitable resins are widely used because of their high specific strength (strength/density) and high specific modulus (modulus/density). Advanced composite materials seem ideally suited for suspension (leaf spring) applications. Their elastic properties can be tailored to increase the strength and reduce the stresses induced during application.

MODELING AND ANALYSIS

- Modeling of Steel leaf spring and E-Glass/Epoxy composite leaf spring using CATIA V5 [5].
- Static analysis of Steel leaf spring, E-Glass/Epoxy composite leaf spring, using ANSYS software [3].
- Modal analysis of Steel and E-Glass/Epoxy composite leaf spring to find the natural frequency so as to investigate the ride quality [4].

Leaf Spring

Leaf springs are made out of flat plates. 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. 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 center of the arc provides location for the axle, while tie holes called eyes 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 layers, often with progressively shorter leaves. Leaf springs can serve locating and to some extent damping as well as springing functions.

Design Specifications

Table 1

S. No	Symbol	Unit	Value
1	E *x*	Mpa	34000
2	E *y*	Mpa	6530
3	E *z*	Mpa	6530
4	S *t*	Mpa	900
5	S *c*	Mpa	450
6	G *xy*	Mpa	2433
7	G *yz*	Mpa	1698
8	G *xz*	Mpa	2433
9	ν*xy*	NUxy	0.217
10	ν*yz*	NUyz	0.366
11	ν*xz*	NUxz	0.217
12	ρ	Kg/mm^3	2.6e-6

Loads Applied

Table 2

S. No	Leaf	Load (N)
1	STEELMASTER LEAF	6000
2	STEEL SECOND LEAF	6000
3	NO OF LEAFS	6000
4	COMPOSITE LEAF	6000

The Following Parts Were Modeled In Catia V5

Master Leaf Spring (Steel)

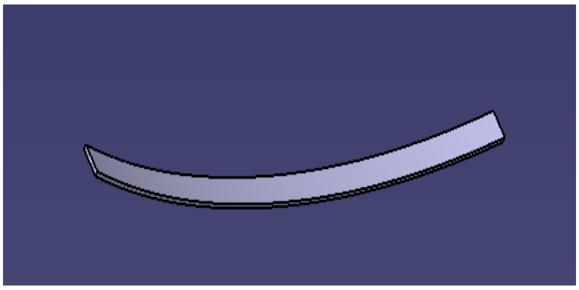

Figure 1

No of Steel Leaf Springs

Above three type of springs is modeled in CATIA as per dimensions.

- CATIA part file is saved as IGES file.
- Master leaf (steel) IGES file is imported to ansys
- In the preferences, structural mode was selected.
- Element type [2] selected was SOLID 42
    - Master leaf designed in CATIA
    - Material properties selected in material model were structural – linear –elastic – isotropic and the values of Young's modulus and Poisson's ratio for steel were entered.

- In the mesh section the volume was meshed with solid tetrahedral elements

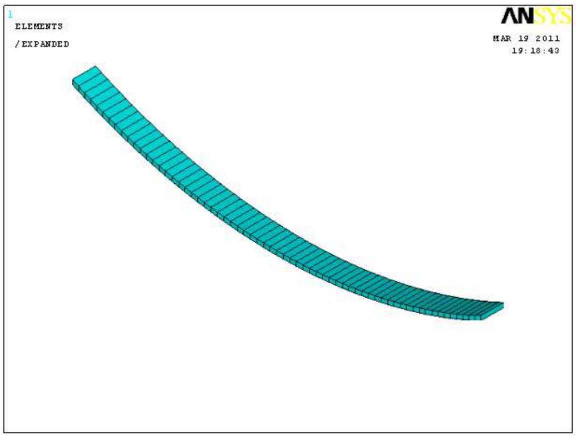

Figure 2

Meshed Master Leaf Designed in CATIA

RESULTS AND DISCUSSIONS

Deflection in no of Leafs(Steel)

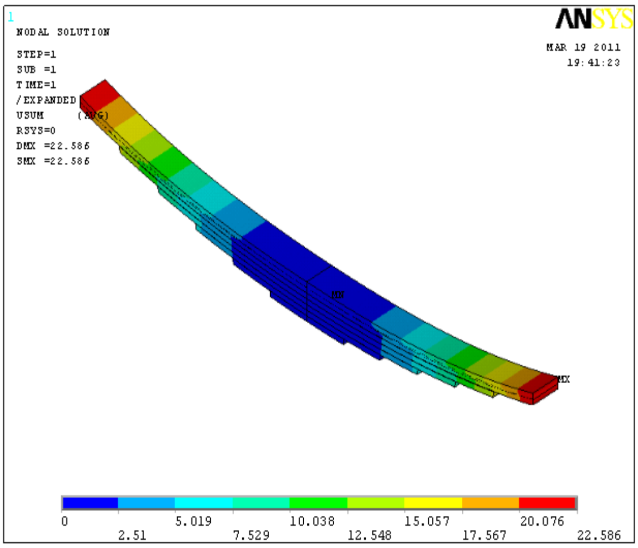

Figure 3

Displacement Vector Sum (No of Steel Leaf)

Von Mises Stress (no of Steel Leaf)

COMPOSITE LEAF SPRING

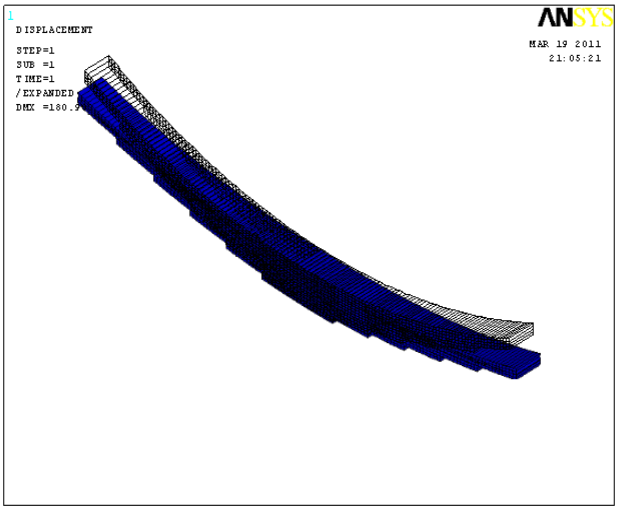

Figure 4

Deflection in No of Leaf Spring (Composite)

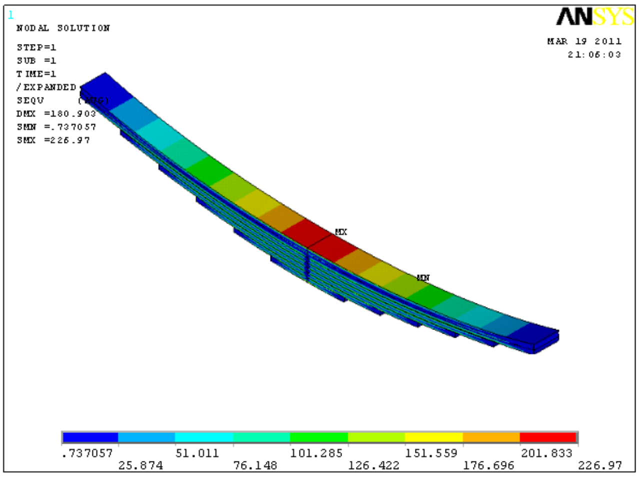

Figure 5

Displacement Vector Sum (No of Composite Leafs)

Stress Analysis

Vonmises Stresses

Table 3

Leaf	Material	Vonmises Stress(Mpa)		Th. Stress
		MAX	MIN	
Master Leaf	Steel	1083	16.668	1100
Master Leaf	Composite	1082	16.671	
2 Full Length Leafs	Steel	541.34	2.872	550
2 Full Length Leafs	Composite	541.535	2.258	
No Of Leafs	Steel	213.266	0.132	206.25
No Of Leafs	Composite	226.97	0.737	

Deflection in Leaf Spring

Table 4

Leaf	Material	Deflection(Mm)
Master leaf	Steel	116.668
	Composite	868.99
Two leafs	Steel	58.134
	Composite	109.276
No of leafs	Steel	22.586
	Composite	180.903

CONCLUSIONS

The E-Glass/Epoxy composite leaf spring was modeled and analyzed to replace the conventional steel leaf spring in the suspension system of automobiles. It was observed that the stress in the composite leaf spring was almost equal so we can say that composite spring had the same stiffness as that of steel spring. It was observed that the composite leaf spring weighed only one-half of the steel leaf spring for the analyzed stresses. Hence the weight reduction obtained by using composite leaf spring as compared to steel was **65.78%**.

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