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Analysis of Glass Epoxy Reinforced Monolithic Leaf Spring

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Abstract: *The automobile industry has been showing an interest in the replacement of steel spring with fiberglass composite leaf spring because of its high strength to weight ratio. Therefore the aim of this paper is to design and analyze composite mono leaf spring of constant width and thickness having the same bending stiffness of semi-elliptical laminated leaf spring. Stress analysis was done by using analytical method and results obtained by analytical methods are compared with ansys. The results obtained by analytical methods showed good agreement with ansys results. A Tsai-Hill failure criterion was used to check whether stresses are within reasonable levels for each ply. The stresses induced in the composite leaf springs were found to be 33.79% less compared to steel leaf spring. When steel leaf spring is replaced by composite leaf spring a weight reduction of 77.29% is obtained , 2.23 times higher natural frequency, 1.371 times more strain energy storage capacity, 33.79 % lesser stress and lesser value of spring rate is obtained in the composite leaf spring compared to steel leaf spring.*
Keywords: *Monolithic, Stress Analysis, Natural Frequency, Strain Energy, Glass Epoxy.*

I. Introduction

The newest innovation in leaf-spring technology is the composite design, or what some would call a fiberglass leaf, although there are other materials involved in the construction of these products. Composite leaf springs are a new concept.

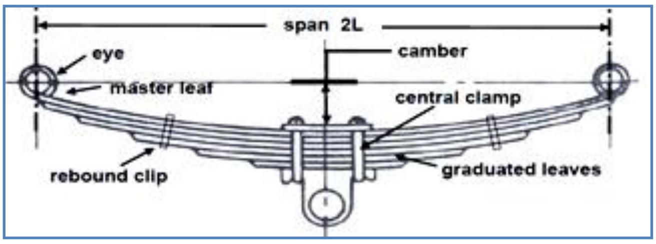

Fig: 1 A laminated semi- elliptic leaf spring.

The primary advantages of using a composite leaf spring are a 60-70 percent weight savings over steel springs and the tendency of the composite spring to maintain its shape, it doesn't sag. The composite leaf springs, just like the steel, come in various rates from 35 to 250 pounds. They can be used as a "single" leaf in low rates or as a "stack" leaf, still a mono-design but thicker (like a stacked steel spring). Even a small amount in weight reduction of the vehicle, may have a wider economic impact. Composite materials are proved as suitable substitutes for steel in connection with weight reduction of the vehicle. Hence, the composite materials have been selected for leaf spring design.

II. Problem Description & Formulation

A semi-elliptical leaf spring is chosen for analysis Using FEA by considering a simple supported beam with a concentrated load at the center. Composite beam material Fiber is Glass (Reinforcement Phase) and Matrix is Epoxy. Consider laminate of ten layers each of 2.9528 mm thick. Then thickness of the laminate is 29.9528 mm. Initially consider ten laminas of Zero degree orientations for ease of manufacturing for hand layup process. A Flow Chart for design Calculation is formulated as follows.

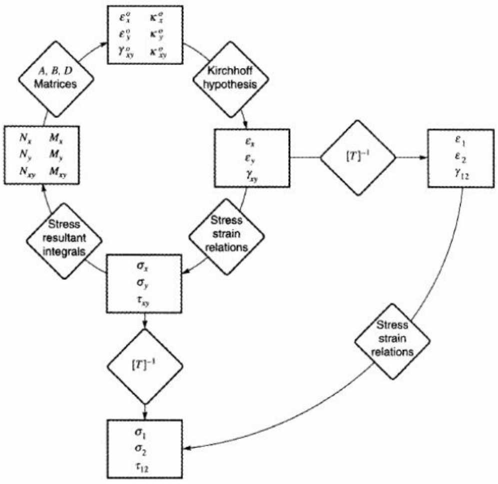

Fig: 2 Calculation Spiral flow chart

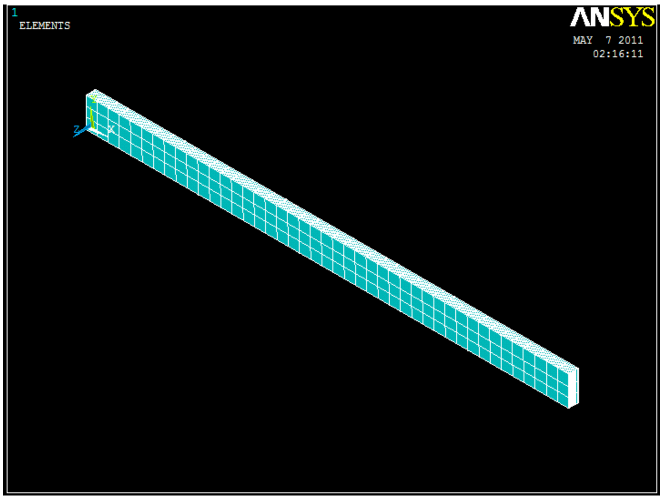

Fig: 3 Isometric view of model

III. Result Analysis And Validation

Stress Analysis of composite leaf spring was done using Ansys for composite leaf spring of constant width and constant thickness so as to compare the results of stress analysis obtained analytically.

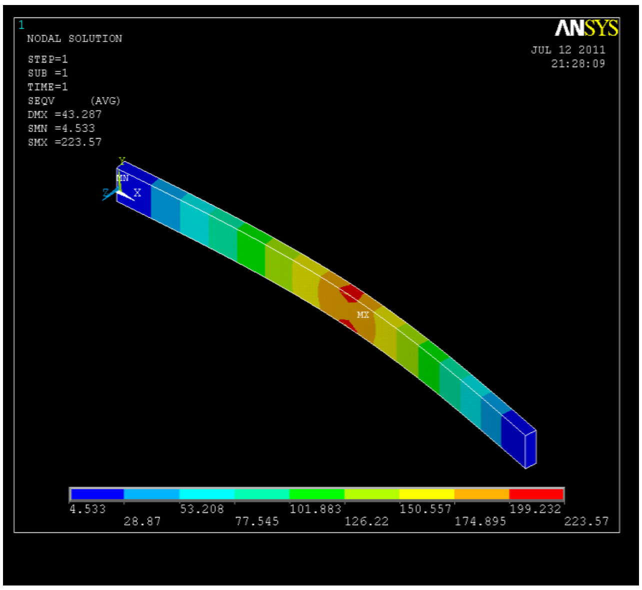

Fig: 4 Isometric view of model

The value of Spring Rate for a steel leaf spring found analytically (K) = 187.4507 N/mm. The following is the comparison table of load, max stress and deflection of composite leaf spring calculated analytically and using Ansys for 0.6 fiber volume fraction.

Load	Deflection (mm)		Stress (MPa)	
(N)	Analytical	Ansys	Analytical	Ansys
0.0	0.000	0.0000	0.000	0
1000.0	5.093	5.2090	27.955	28.364
2000.0	10.186	10.4170	55.911	56.728
3000.0	15.279	15.6260	83.866	85.092
4000.0	20.372	20.8350	111.822	113.456
5000.0	25.465	26.0440	139.777	141.82
6000.0	30.558	31.2520	167.733	170.183
7000.0	35.651	36.4610	195.688	198.547
7500.0	38.196	43.287	209.665	223.57

Table: 1 Load, Deflection and Stress for 0.6 Fiber Volume Fraction

Load	Deflection (mm)		Stress (MPa)	
(N)	Analytical	Ansys	Analytical	Ansys
0.0	0.000	0.0	0.000	0.0
1000.0	4.725	4.7	27.955	28.4
2000.0	9.448	9.5	55.911	56.7
3000.0	14.172	14.2	83.866	85.1
4000.0	18.896	18.9	111.822	113.4
5000.0	23.620	23.7	139.777	141.8
6000.0	28.344	28.4	167.733	170.1
7000.0	33.068	33.1	195.688	198.5
7500.0	35.435	35.5	209.665	212.6

Table: 2 Load, Deflection and Stress for 0.65 Fiber Volume Fraction

Load	Deflection (mm)		Stress (MPa)	
(N)	Analytical	Ansys	Analytical	Ansys
0.0	0.000	0.0000	0.000	0
1000.0	4.406	4.4120	27.955	28.364
2000.0	8.812	8.9120	55.911	56.728
3000.0	13.218	13.5670	83.866	85.092
4000.0	17.624	17.7340	111.822	113.456
5000.0	22.030	22.2010	139.777	141.82
6000.0	26.436	26.6750	167.733	170.183
7000.0	30.842	30.8490	195.688	198.547
7500.0	33.046	33.2160	209.665	212.723

Table: 3 Load, Deflection and Stress for 0.7 Fiber Volume Fraction

Material	Weight(Kg)	Strain energy (N- mm) Analytical	Spring Rate (N- mm) Analytical
Steel	28.1856	872146.6551	187.4507
Composite V_f=0.6	6.399	1289126.397	196.3556
Composite V_f=0.65	6.399	1195936.527	211.655
Composite V_f=0.7	6.399	1115311.593	226.956

Table: 4 Comparison of Steel and Composite Leaf Spring

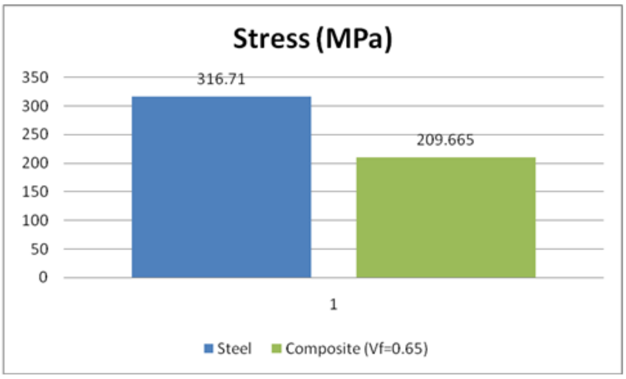

Fig: 4 Comparison of stress for Steel and composite

IV. CONCLUSIONS

- The analytical results were compared with FEA and the results show good agreement.
- 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.
- When steel leaf spring is replaced by composite leaf spring, weight reduction of 77.29% is obtained, 2.23 times higher natural frequency, 1.371 times more strain energy storage capacity, 33.79 % lesser stress and lesser value of strain rate is obtained in the composite leaf spring compared to steel leaf spring is obtained.

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