Static & Dynamic analysis of EN 47 Leaf Spring & E-Glass Fiber with Epoxy Resin Hardner Based unidirection laminated Composite Leaf Spring

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ABSTRACT

Leaf springs are one of the oldest suspension components they are still frequently used, especially in commercial vehicles. The past literature survey shows that leaf springs are designed as generalized force elements where the position, velocity and orientation of the axle mounting gives the reaction forces in the chassis attachment positions. Another part has to be focused, is the automobile industry has shown increased interest in the replacement of steel spring with composite leaf spring due to high strength to weight ratio. Therefore, analysis of the composite material becomes equally important to study the behaviour of Composite Leaf Spring. The objective of this paper is to present modelling and analysis of composite mono leaf spring and compare its results. Modelling is done using CATIA and Analysis is carried out by using ANSYS software for better understanding.

Keywords: *Leaf spring, Composite, E-Glass/Epoxy & FEA, weight reduction, un-sprung weight.*

1. Introduction

Leaf springs are one of the oldest suspension components that are being still used widely in automobiles. Weight reduction is also given due importance by automobile manufacturers. The automobile industry has shown increased interest in the use of composite leaf spring in the place of conventional steel leaf spring due to its high strength to weight ratio. The introduction of composite materials has made it possible to reduce the weight of the leaf spring without any reduction in load carrying capacity and stiffness.

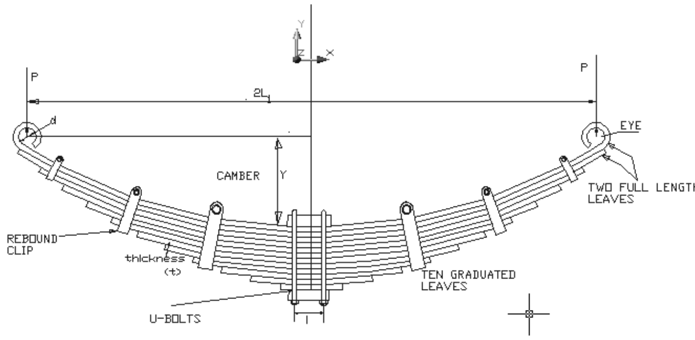

Fig 1.1 Geometry of the steel leaf spring

An advantage of leaf spring over the helical spring is that the end of the spring may be guided along the definite path as it deflects. Thus, the spring may act as a structural member as well as an energy-absorbing device. It can provide all the control for the wheels during acceleration, breaking, corning and general movements caused by the road surface.

2. Experimentation:

2.1 Steel Leaf Spring:

The material used for steel leaf springs is usually 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 produces greater strength & therefore greater load capacity, greater range of deflection & better fatigue properties.

2.1.1Analytical Reading for Steel

I= [bt^3 / 12]

δ = [WL^3/3EI]

σ = [6WL / bt^2]

The dimensional details & physical properties of steel leaf spring are given in table 2.1 & table 2.2

Table 2.1: Steel leaf spring parameters

Parameter	Value
1) Straight length in mm	955
2) Leaf thickness in mm	10
3) Leaf width in mm	50
4) Camber in mm	110
5) No. of graduated leaves	0

Table 2.2: Material Properties EN47 Material

Sr. No	Parameter	Value
01	Ultimate Tensile Strength (Mpa)	1962
02	Yield Tensile strength (Mpa)	1470
03	Young's modulus (Mpa)	2.07×10^5
04	Poisson's ratio	0.3
05	Density (Kg/m3)	7800

Table 2.3: Analytical Reading for Steel

Sr. No.	Load (N)	Steel Leaf Spring	
		Deflection (mm)	Stress (N/mm^2)
1	50	2.10	28.65
2	100	4.21	57.30
3	150	6.31	85.95
4	200	8.41	114.60
5	250	10.52	143.25
6	300	12.62	171.90
7	350	14.73	200.55
8	400	16.83	229.20
9	450	18.93	257.85
10	500	21.04	286.50
11	550	23.14	315.15
12	600	25.25	343.80
13	650	27.35	372.45
14	700	29.46	401.10
15	750	31.56	429.75
16	800	33.67	458.40
17	850	35.77	487.05
18	900	37.87	515.70
19	950	39.98	544.35
20	1000	42.08	573.00

2.1.2 FINITE ELEMENT ANALYSIS

Basic Steps in FEA are:

- Discretization of the domain.
- Application of Boundary conditions.
- Assembling the system equations.
- Solution for system equations.

- Post processing the results.

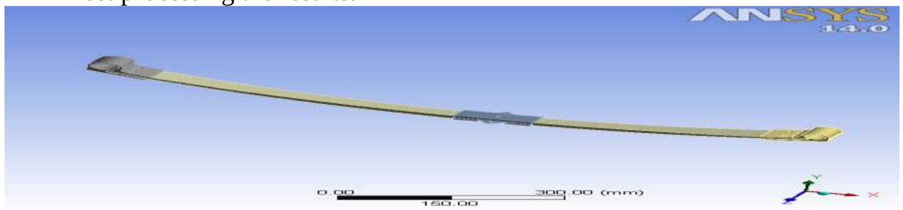

Fig.2.1 Finite Element Modeling

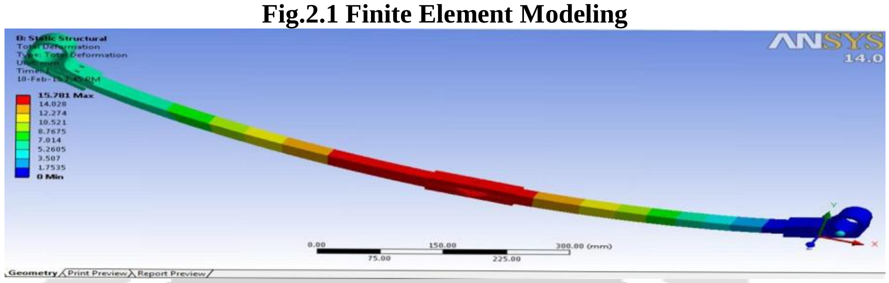

Fig.2.2 Static Analysis

Table 2.4: Stress and Deflection of Leaf Spring for Various Loads by FEA

Sr. No.	Load (N)	Steel Leaf Spring	
		Deflection	Stress
1	50	2.20	28.59
2	100	4.15	57.02
3	150	6.51	85.82
4	200	8.40	114.62
5	250	10.44	143.22
6	300	12.56	171.79
7	350	14.69	200.19
8	400	16.80	229.39
9	450	18.89	257.60
10	500	21.00	286.31
11	550	23.13	315.20
12	600	25.23	343.59
13	650	27.30	372.25
14	700	29.38	400.78
15	750	31.54	429.75
16	800	33.68	459.44
17	850	35.70	487.98
18	900	37.85	517.70
19	950	39.96	546.81
20	1000	42.20	579.10

2.2 Composite Leaf Spring:

Composite materials (or composites for short) are engineering materials made from two or more constituent materials that remain separate and distinct on a macroscopic level while forming a single component. There are two categories of constituent materials: matrix and reinforcement. At least one portion of each type is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties. The primary functions of the matrix are to transfer stresses between the reinforcing fibers/particles and to protect them from mechanical and/or environmental damage whereas the presence of fibers/particles in a composite improves its mechanical properties such as strength, stiffness etc.

Following are the mainly three types of Composite.

I. Metal Matrix Composites (MMC)
II. Ceramic Matrix Composites (CMC)
III. Polymer Matrix Composites (PMC)

The raw materials used in this work are

a) E-glass Fiber

b) Dubeckot 520F Epoxy resin
c) Resin hardener

2.2.1Types of manufacturing processe

- Pultrusion
- Filament Winding
- Lamination type process
- Hand Lay-up Technique

We used a hand-lay-up method to produce the prototype of a single composite leaf spring.

Fig.2.3 Prototype of Composite Leaf Spring

2.2.1.1Analytical Reading for Steel

The dimensional details & physical properties of composite leaf spring are given in table 2.5 & table 2.6

Table 2.5: Composite leaf spring parameters

Parameter	Value
1) St. length in mm	955
2)Leaf thickness in mm at the centre	20
at the end	08
3) Leaf width in mm at the centre	35
at the end	50
4) Camber	110

Table 2.6: Material Properties of Composite Material (24)

Sr. No.	Parameter	Value
01	UTS (Mpa)	1374
02	Yield Tensile strength (Mpa)	1030
03	Young's modulus (Mpa)	39000 N/mm^2
04	Poisson's ratio	0.3
05	Density (Kg/m^3)	$2.6x10^{-6}$

Table 2.7: Analytical Reading for Composite

Sr. No.	Load (N)	Composite Leaf Spring	
		Deflection (mm)	Stress (N/mm^2)
1	50	1.99	10.20
2	100	3.98	20.40
3	150	5.98	30.60
4	200	7.97	40.80
5	250	9.97	51.00
6	300	11.96	61.20
7	350	13.96	71.40
8	400	15.95	81.60
9	450	17.94	91.80
10	500	19.94	102.00
11	550	21.93	112.20
12	600	23.93	122.40
13	650	25.92	132.60
14	700	27.92	142.80
15	750	29.91	153.00
16	800	31.91	163.20
17	850	33.90	173.40
18	900	35.89	183.60
19	950	37.89	193.80
20	1000	39.88	204.00

FINITE ELEMENT ANALYSIS:

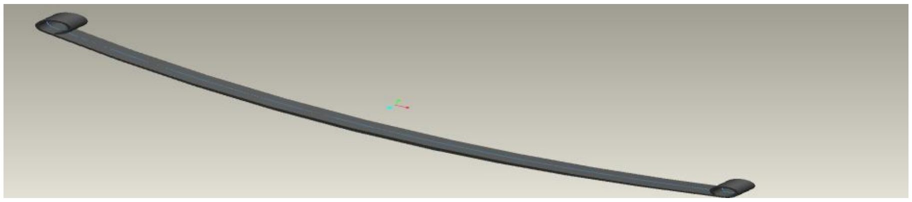

Fig.2.4 Finite Element Modeling

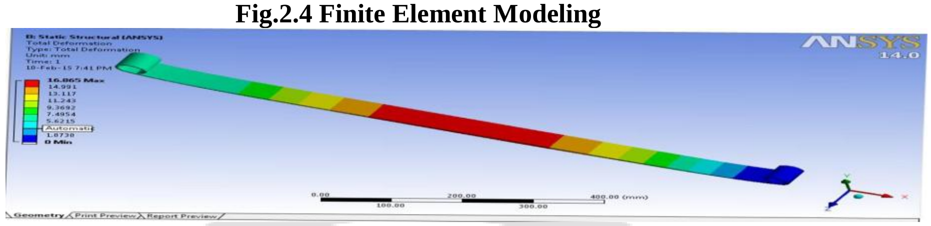

Fig.2.5 Static Analysis

Table 2.8: Stress and Deflection of Leaf Spring for Various Loads by FEA

Sr. No.	Load (N)	Composite Leaf Spring	
		Deflection	Stress
1	50	2.03	10.32
2	100	4.01	20.41
3	150	5.95	30.60
4	200	7.98	40.79
5	250	9.99	50.89
6	300	11.94	61.20
7	350	13.93	71.62
8	400	15.94	81.63
9	450	17.92	91.74
10	500	19.98	101.93
11	550	21.88	111.98
12	600	23.94	122.41
13	650	25.92	132.56
14	700	27.89	142.60
15	750	29.90	153.21
16	800	31.90	163.18
17	850	34.00	173.39
18	900	35.88	183.89
19	950	37.89	193.56
20	1000	40.36	204.91

3. Result and Discussion:

The variations of bending stress with load are shown in Table 3.1 & 3.2. It shows that the composite leaf spring have better withstand capacity than the steel leaf spring.

Table 3.1 Comparison of results for steel leaf spring

Sr. No.	Parameter	Analytical value	FEM value
1	Load (N)	1000	1000
2	Deflection (mm)	42.08	42.20
3	Bending stress in (N/mm^2)	573.00	579.10

Table 3.2 Comparison of results for composite leaf spring

Sr. No.	Parameter	Analytical value	FEM value
1	Load (N)	1000	1000
2	Deflection (mm)	39.88	40.36
3	Bending stress in (N/mm^2)	204.00	204.91

4. Conclusion:

The automobile industries are looking for cost effective composite leaf spring with minimum mass, capable of resisting corrosion and possessing a high degree of durability and selecting on the basis of less wear, damage, lower sensitivity to crack & impact and fatigue resistance.

From all study it is seen that-

- Strength and stiffness of composite leaf spring is more than steel spring
- Composite leaf spring gives more comfort
- Test ride, noise and hardness are significantly reduced
- More flexible than steel leaf spring
- High specific strength, rigidity

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