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Comparative Study Of EN 47 Leaf Spring & E-Glass Fiber With Epoxy Resin Hardner Based Unidirection Laminated Composite Leaf Spring

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Abstract

In this project we look on the suitability of composite leaf spring on vehicles and their advantages. Efforts have been made to reduce the cost of composite leaf spring to that of steel leaf spring. The achievement of weight reduction with adequate improvement of mechanical properties has made composite a very replacement material for convectional steel. 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 leaf spring using E-Glass/Epoxy unidirectional laminates. Static analysis of model of conventional leaf spring is performed and compared with experimental results carried out through Universal Testing Machine.

Keywords: *Leaf spring, Composite, E-Glass/Epoxy, 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.

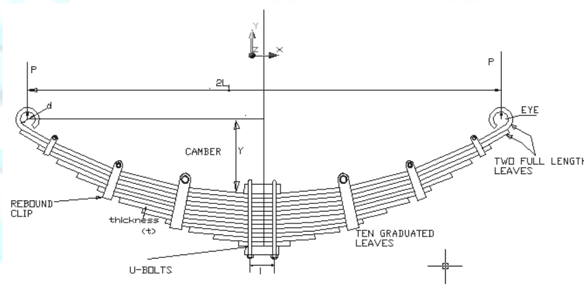

Fig 1.1 Geometry of the steel leaf spring

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

$I = [\ bt^3 / 12\ ]$

$\delta = [WL^3/3EI]$

$\sigma = [6WL / bt^2\ ]$

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 Experiment

The spring to be tested is examined for any defects like cracks, surface abnormalities etc. The dimensional & material details of the leaf spring are recorded. First of all the steel leaf spring is mounted on the leaf spring mounting fixture of the testing machine (UTM).

Table 2.4: Bending stress Value for EN47 Leaf Spring

Sr. No.	Load	Deflection	Bending
1	50	3.10	29.22
2	100	4.90	59.39
3	150	7.20	88.67
4	200	8.70	115.89
5	250	11.30	145.10
6	300	13.44	173.69
7	350	14.98	203.55
8	400	16.70	231.48
9	450	19.00	259.11
10	500	21.50	289.50
11	550	23.65	317.90
12	600	24.99	375.33
13	650	26.98	404.14
14	700	29.10	433.62
15	750	31.53	461.32
16	800	33.62	490.17
17	850	36.01	518.21
18	900	38.12	548.32
19	950	40.32	576.09
20	1000	43.50	605.21

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

2.2.1.1Analytical Reading for composite

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)	2.6×10^{-6}

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Table 2.7: Analytical Reading for Composite

Sr. No.	Load (N)	Composite Leaf Spring	
		Deflection (mm)	Stress (N/mm²)
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

Experiment:
After completion of test on steel leaf spring, composite leaf spring is mounted on the fixture & the same procedure is repeated.

Table 2.8: Bending stress Value for Composite Leaf Spring

Sr. No.	Deflection	Load	Bending Stress
1	50	2.40	10.57
2	100	4.20	21.29
3	150	6.76	30.98
4	200	8.99	41.22
5	250	10.10	52.39
6	300	12.20	62.55
7	350	14.18	73.62
8	400	16.40	82.21
9	450	18.34	93.02
10	500	20.56	104.00
11	550	22.04	114.51
12	600	24.10	125.17
13	650	26.31	135.44
14	700	28.98	145.81
15	750	31.02	156.10
16	800	33.57	167.63
17	850	35.84	177.40
18	900	37.00	188.32
19	950	39.30	198.79
20	1000	41.45	208.52

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.

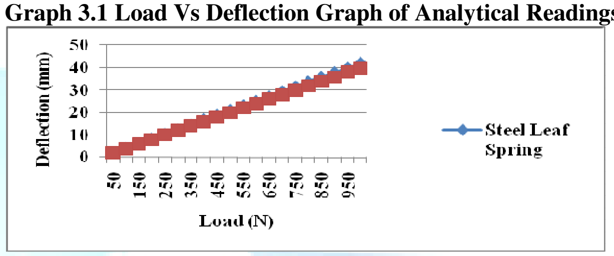
Table 3.1 Comparison of results for steel leaf spring

Sr. No.	Parameter	Analytical	Expt. Value
1	Load (N)	1000	1000
2	Deflection (mm)	42.08	43.502
3	Bending stress in	573.00	605.21

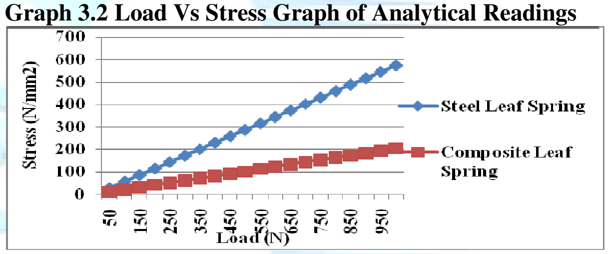
Table 3.2 Comparison of results for composite leaf spring

Sr. No.	Parameter	Analytical	Expt. Value
1	Load (N)	1000	1000
2	Deflection (mm)	39.88	41.45
3	Bending stress in	204.00	208.52

Graph 3.1 Load Vs Deflection Graph of Analytical Readings



Graph 3.2 Load Vs Stress Graph of Analytical Readings



From the Graph 3.1 & 3.2 it is clear that in the composite leaf spring, less bending stresses occurs as compared to steel leaf spring for the same load.

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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