International Journal For Technological Research In Engineering
Volume 6, Issue 9, May-2019 *ISSN (Online): 2347 - 4718*

OPTIMIZATION OF A LEAF SPRING BY ANSYS SOFTWARE

Pragnesh B. Satasiya[1], Maulesh Parikh[2], Darshan Dodiya[3], Prof. Siddharth Tirole[4]
[1, 4]Mechanical Engineering Department, Silver Oak Engineering College, Ahmedabad.
[2]Mechanical Engineering Department, Gujarat Technological University, Vadodara.
[3]Mechanical Engineering Department, National Institute of Technology, Surat.

Abstract: The main reason of failure for composites in vehicle suspension applications is in its principal direction instead of shear. This can be fulfilled efficiently by employing a new composite configuration instead of existing one with conventional material. This study introduces a comparison of different composite material with semi-elliptical suspension spring by utilizing its strength in principal direction instead of shear direction. The automobile industry has shown increased interest in the replacement of steel spring with composite leaf spring due to high strength to weight ratio and improved damping. Therefore, the finite element results using ANSYS software showing stresses and deflections with different composite materials.

Keywords: leaf spring; composite; analysis, ANSYS, Finite element, Spring rate.

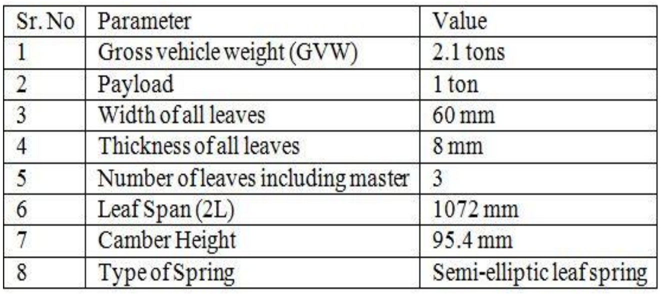
I. INTRODUCTION

In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturer in the present scenario. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. The suspension leaf spring is one of the potential items for weight reduction in automobile as it accounts for ten to twenty percent of the unsprung weight. This helps in achieving the vehicle with improved riding qualities. It is well known that springs, are designed to absorb and store energy and then release it. Hence, the strain energy of the material becomes a major factor in designing the springs. In recent year, with the development of new material and new technology, foreign auto companies begin to introduce composite leaf spring.

II. DESIGN OF A SEMI-ELLIPTICAL SPRING

Leaf spring of vehicle TATA ACE MEGA XL is selected for the optimization. Table 1 shows the details of the Tata Ace Mega XL.

Table 1: Basic Details of Vehicle



Sr. No	Parameter	Value
1	Gross vehicle weight (GVW)	2.1 tons
2	Payload	1 ton
3	Width of all leaves	60 mm
4	Thickness of all leaves	8 mm
5	Number of leaves including master	3
6	Leaf Span (2L)	1072 mm
7	Camber Height	95.4 mm
8	Type of Spring	Semi-elliptic leaf spring

Leaf Spring geometry parameters are shown in Table 2.

Table 2: Geometry parameters

Parameter	Value	Unit
n	3	-
L	536	mm
b	60	mm
t	8	mm

Mass details of leaf is shown in Table 3.

Table 3: Leaf Volume Details

Sr. No.	Leaf	Volume (cm^3)
1	Main (Top)	339.26
2	Intermediate (Middle)	263.36
3	Graduated (Bottom)	263.36
	Total Volume	865.98

Mechanical Properties of a convention spring material is listed in Table 4.

Table 4: Material Properties

Parameter	Value
Modulus of Elasticity	210 GPa
Poisson's Ratio	0.29
Density	7850 kg/m^3

From above tables, mass of the conventional leaf spring is 6.8 kg.

III. ANALYSIS OF SPRING

Geometrical model of a leaf spring has been prepared using the available data in the Ansys workbench 19.1 as which is shown in figure 1.

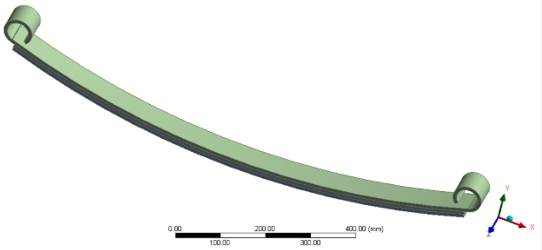


Figure 1 Geometrical model

Following equation is used for the deformation optimization of the spring.

$$\delta = \frac{6 \, X \, P \, X \, L^3}{E \, X \, n \, X \, b \, X \, t^3}$$ ………………..Eq 1.

Where,
P = load on the spring (N), L length of the spring (mm)

n = number of leaves, b = width of leaf (mm)
E = modulus of elasticity (MPa), t = thickness of leaves (mm)

From Equation 1, it is cleared that deformation of spring is inversely proportional to a modulus of elasticity and number of leaves presented in the spring.

IV. OPTIMIZATION OF A SPRING

From Equation 1, to control the spring deformation, E value of a composite leaf spring must be greater than 210 GPa with three number of leaves.

Equation 1 can be written as with comparison of leaves and modulus of elasticity,

$$\delta \propto \frac{1}{E\,x\,n} = \frac{1}{210\,x\,3} = \frac{1}{315\,x\,2} = \frac{1}{630\,x\,1} \quad \ldots\text{Eq 2}$$

Therefore, there are total three constrains of a composite selection as per following:

1. 210 GPa < E < 315 GPa
2. 315 GPa < E < 630 GPa
3. E > 630 GPa

The list is prepared with some known composites as per Table 5.

Table 5: Material properties of composites

Fiber Name	Density (g/cm^3)	Tensile strength(MPa)	E (GPa)
E-glass	2.6	2000	70
HS glass	2.5	4200	83
Aramid	1.4	3200	124
Boron	2.6	3600	400
SM carbon(PAN)	1.7	3200	235
UHM carbon (PAN)	1.9	3800	590
UHS carbon (PAN)	1.8	7000	290
UHM carbon (pitch)	2.2	2200	895
UHK carbon (pitch)	2.2	2200	830
Sic monofilament	3	3600	400
Sic multifilament	3	3100	400
Si-C-O	2.6	2900	190
Si-Ti-C-O	2.4	3300	190
Aluminum oxide	3.9	1900	370
High density Polyethylene	0.97	3000	172
Basalt	2.7	2900	100
Silicon carbide	2.9	-	520
Alumina	3.9	-	380

Simulation has been carried out in number of iterations by varying the number of leaves. In this study three iterations have been performed on leaf spring with three leaves, two leaves, and single leaf respectively based on optimization constrains.

Iteration 1: Three number of leaves;

To control the deformation, E value must be greater than 210 GPa with three number of leaves. Materials having the value of elasticity more than 210 GPa are listed in the following Table 6.

Table 6: Material list according to Constrain 1

Sr. No.	Composite Name	Density (g/cm^3)	Modulus (GPa)
1	SM carbon (PAN)	1.7	235
2	UHS carbon (PAN)	1.8	290

From the above table, SM carbon is having minimum density among all material, therefore SM carbon is selected for the analysis.

Iteration-2: Two number of leaves.

With two number of leaves, E value must be as per constrain 2. Table 7 shows the material list based on constrain 2.

Table 7: Material list according to Constrain 2

Sr. No.	Composite Name	Density (g/cm3)	Modulus (GPa)
1	Boron	2.6	400
2	SiC monofilament	3.0	400
3	SiC multifilament	3.0	400
4	Aluminum oxide	3.9	370
5	Alumina	3.9	380
6	UHM carbon (PAN)	1.9	590
7	Silicon carbide	2.9	520

UHM carbon (PAN) is having minimum density among all material, therefore it is selected for the analysis.

Iteration-3: Single leaf

With a single leaf, E value must be as per constrain 3. Table 8 shows the material list based on constrain 3.

Table 8: Material list according to Constrain 3

Sr. No.	Composite Name	Density (g/cm^3)	Modulus (GPa)
1	UHM carbon (pitch)	2.2	895
2	UHK carbon (pitch)	2.2	830

As per Table 8, density is same for both material, but modulus is more for UHM carbon (pitch), so it is selected for the analysis.

V. LOAD CASE

There are two load cases performed for all iterations:

- Fully loaded condition
- Self-Weight condition without payload

VI. BOUNDARY CONDITION

All dofs except rotation of Z are restricted at eye location.

VII. LOADING CONDITION

Full load/Partial load is applied at center of the leaf spring.

VIII. RESULTS

Analysis has been carried out by all applicable materials while results are shown for optimal spring configuration.

Load Case 1

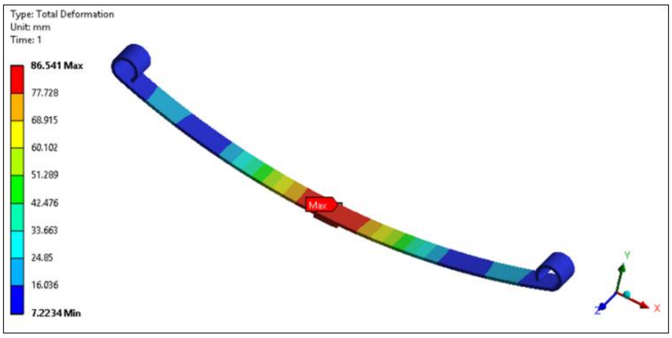


Figure 2: LC-1 Deformation (mm)

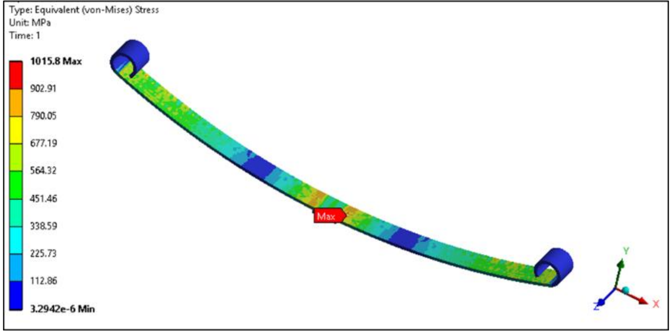


Figure 3: LC-1 Stress (MPa)

Load Case 2

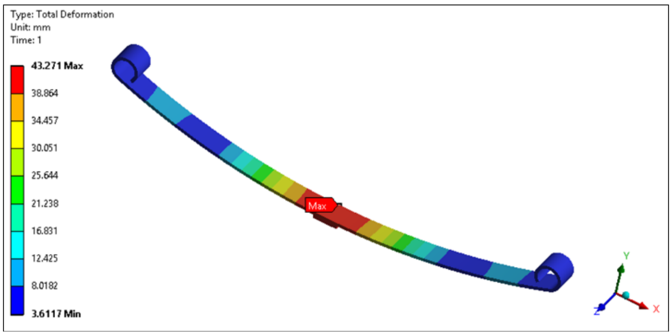


Figure 4: LC-2 Deformation (mm)

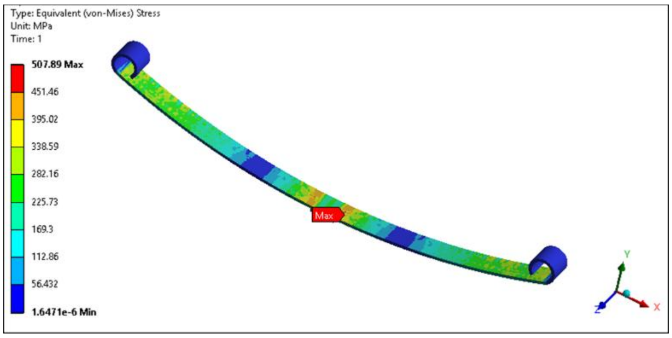


Figure 5: LC-2 Stress (MPa)

IX. CONCLUSION

- Mass of the optimal spring is reduced from 6.8 kg to 0.75 kg.
- Stress and deformation observed are within limit.
- The study demonstrated that composites can be used for leaf springs for light weight vehicles and meet the requirements, together with substantial weight savings;
- From the results, it is observed that the composite leaf Spring is lighter than the conventional steel spring with similar design specifications.

REFERENCES

[1] F.C. Campbell, Introduction to Composite Materials, ructural Composite Materials, 05287G, ASM International, 2010 [3] Schwartz MM, “Composite materials handbook.” Mac Graw-Hill, USA, 2nd Edition, 1992, 34-35.

[2] Schwartz MM, “Composite materials handbook.” Mac Graw-Hill, USA, 2nd Edition, 1992, 34-35.

[3] Mukhopadhyay M, “Mechanics of composite materials and structures.” University Press (India), Pvt. Ltd.1-10.

[4] Smith WF, “Principles of materials science and engineering.” MacGraw-Hill, 1990, pp. 699-724.

[5] K. Ashwini et al., Design and Analysis of Leaf Spring using Various Composites–An Overview, Materials Today: Proceedings 5 (2018) 5716–5721.

[6] Zheng Yinhuan, Xue Ka, Huang Zhigao, Finite Element Analysis of Composite Leaf Spring, Computer Science & Education (ICCSE 2011) August 3-5, (2011) Super Star Virgo, Singapore.

[7] Mahmood M. Shokrieh*, Davood Rezaei, Analysis and optimization of a composite leaf spring, Composite Structures 60 (2003) 317–325

[8] J.P. Hou, J.Y. Cherruault, I. Nairne, G. Jeronimidis, R.M. Mayer, Evolution of the eye-end design of a composite leaf spring for heavy axle loads, Composite Structures 78 (2007) 351–358