ISSN 2395-1621

Design and Analysis of Mono-Composite Leaf Spring

[#1]Ajitkumar G. Nimbalkar, [#2]S. P. Deshmukh

[1]nimbalkarag777@gmail.com
[2]suhas.deshmukh@gmail.com

[1]M. E. (Design Enginering) Mechanical Engineering Department,
Sinhgad academy of engineering Kondhwa(BK),Pune,
Maharashtra, India
[2]Professor, Mechanical Engineering Department,
Sinhgad academy of engineering Kondhwa(BK),Pune,
Maharashtra, India

ABSTRACT

The automobile industry has shown interest in reduction in weight of the vehicles. Therefore, due to their high strength-to-weight ratios, in the last decades there is a large use of composite materials in the aviation and automotive industry, replacing the conventional materials (i.e. steel). Leaf springs are one of the oldest suspension components that are being still used widely in automobiles. The objective of this paper is to replace the multi-leaf steel spring by mono composite leaf spring for the same load carrying capacity and stiffness. Since the composite materials have more elastic strain energy storage capacity and high strength-to-weight ratio, good corrosion resistance as compared to those of steel. It is possible to reduce the weight of the leaf spring without any reduction on load carrying capacity and stiffness. The materials used for mono-composite leaf spring is glass fiber and Epoxy resin. Steel and mono-composite leaf spring modeled in Catia software and analysis is done using ANSYS software.

*Keywords***— Composites, Epoxy resin and Glass fiber, Leaf springs.**

ARTICLE INFO

Article History

Received :18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

I. INTRODUCTION

Leaf springs are mainly used in suspension systems to absorb shock loads in automobiles like light motor vehicles, heavy duty trucks and in rail systems. It carries lateral loads, brake torque, driving torque in addition to shock absorbing. According to the studies made a material with maximum strength and minimum modulus of elasticity in the longitudinal direction is the most suitable material for a leaf spring. To meet the need of natural resources conservation, automobile manufacturers are attempting to reduce the weight of vehicles in recent years. 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 automobiles unsprung weight. This achieves the vehicle with more fuel efficiency and improved riding qualities. The introduction of composite materials was made it possible to reduce the weight of leaf spring without any reduction on load carrying capacity and stiffness. For weight reduction in automobiles as it leads to the reduction of un-sprung weight of automobile. The elements whose weight is not transmitted to the suspension spring are called the un-sprung elements of the automobile. This includes wheel assembly, axles, and part of the weight of suspension spring and shock absorbers. The leaf spring accounts for 10-20% 0f the un-sprung weight. The composite materials made it possible to reduce the weight of machine element without any reduction of the load carrying capacity.

Because of composite material’s high elastic strain energy storage capacity and high strength-to-weight ratio compared with those of steel. FRP springs also have excellent fatigue resistance and durability. But the weight reduction of the leaf spring is achieved not only by material replacement but also by design optimization. Weight reduction has been the main focus of automobile manufacturers in the present scenario.

The replacement of steel with optimally designed composite leaf spring can provide 92% weight reduction. Moreover the composite leaf spring has lower stresses compared to steel spring. All these will result in fuel saving which will make countries energy independent because fuel saved is fuel produced. The introduction of composite materials was made it possible to reduce the weight of the leaf spring without any reduction on load carrying capacity and stiffness. Since, the composite materials have more elastic strain energy storage capacity and high strength-to-weight ratio as compared to those of steel.

The introduction of fiber reinforced plastics (FRP) made it possible to reduce the weight of a machine element without any reduction of the load carrying capacity. Because of FRP materials high elastic strain energy storage capacity and high strength-to-weight ratio compared with those of steel, multi-leaf steel springs are being replaced by mono leaf FRP springs.[1,2]

II. METHODOLOGY

ANSYS is engineering simulation software used for general purpose finite element analysis andfor numerically solving mechanical problems. Here ANSYS 13.0 is used for analyzing the performance of conventional and composite leaf spring. Leaf spring is modelled in Catia V5software and it is imported in ANSYS 13.0. The conventional steel leaf spring and the composite leaf spring were analyzed under similar conditions using ANSYS software and the results are presented in Table 1.

A. Specifications for Steel Leaf Spring

The specifications of leaf spring used in Ambassador car is given in table no 1.
Material used for steel leaf spring is 55 Si 2 Mn90 steel.

TABLE 1
SPECIFICATIONS FOR STEEL LEAF SPRING

Parameters	value
Length of master leaf spring 1200mm	1200 mm
Free camber	200 mm
Thickness	6 mm
Width 50mm	50 mm
Ineffective length	200 mm
Number of graduated leaves	6
Length of second leaf	1150 mm
Length of third leaf	1000 mm
Length of fourth leaf	700 mm
Length of fifth leaf	580 mm
Length of sixth leaf	430 mm
Length of seventh leaf	300 mm

B. Design calculations

Deflection $\delta = 12\ WL^3/Ebt^3\ (2n_G+3n_F)$ ... (1)
$= 12 \times 4000\times500^3/2.1\times10^5\times50\times6^3(2\times6+3\times1)$
$= 176.36$ mm
Bending stress $\sigma= 18\ WL/bt^2\ (2n_G+3n_F)$... (2)
$= 18\times4000\times500/50\times6^2(2\times6+3\times1)$
$= 222.22$N/mm2

C. Selection of Composite Material

As mentioned earlier, the ability to absorb and store more amount of energy ensures the comfortable operation of suspension system. However problem of heavy weight of spring is still persistent. This can be remedied by introducing composite materials, in place of steel in the conventional leaf spring.

Research has indicated that the result of E-Glass/Epoxy were found with good characteristics for storing strain energy.[5] So, a virtual model of leaf spring was created in Catia V5. Model is imported in ANSYS and then material is assigned to the model. This result can be used for comparison with the conventional steel leaf spring.

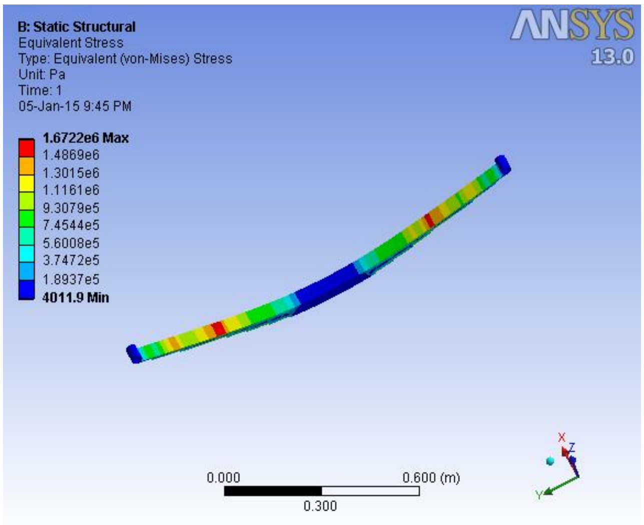
D. Analysis of Leaf Spring using ANSYS

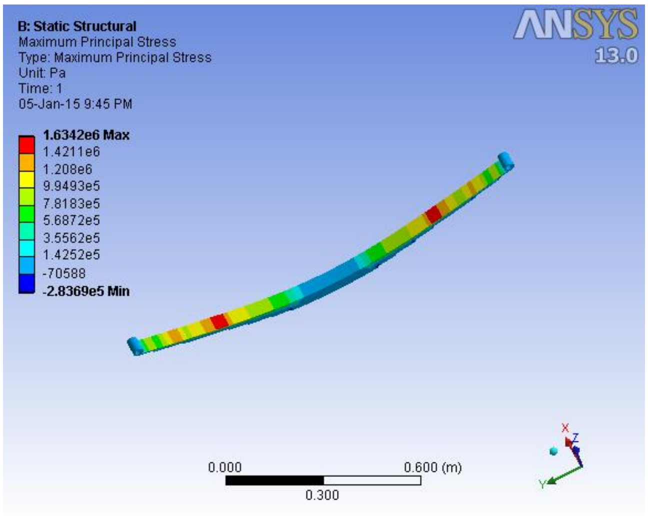
All the analysis for the springs is done by using ANSYS 13.0. For composite leaf spring the same parameters are used as that of conventional leaf spring. For designing of leaf spring the camber is taken as 200 mm.Leafspring is modelled in Catia V5 software and it is imported in ANSYS 13.0.

The constraint is given at the two eye-rolled ends. One of the end is provided with translational movement so as to adjust with the deflection. This eye end is free to travel in longitudinal direction .This particular motion will help leaf spring to get flattened when the load is applied. The stress and deflection analysis is done for conventional and composite leaf spring using ANSYS software.

The results for both composite and conventional leaf spring is compared and given below.

E. ANSYS Results for Conventional Leaf Spring





Sr.No.	Properties	Value
1.	Tensile modulus along X-direction (Ex), MPa	34000
2.	Tensile modulus along Y-direction (Ey), MPa	6530
3.	Tensile modulus along Z-direction (Ez), MPa	6530
4.	Tensile strength of the material, MPa	900
5.	Compressive strength of the material, MPa	450
6.	Shear modulus along XY-direction (Gxy), MPa	2433
7.	Shear modulus along YZ-direction (Gyz), MPa	1698
8.	Shear modulus along ZX-direction (Gzx), MPa	2433
9.	Poisson ratio along XY-direction (NUxy)	0.217
10.	Poisson ratio along YZ-direction (NUyz)	0.366
11.	Poisson ratio along ZX-direction (NUzx)	0.217
12.	Mass density of the material (ρ), kg/mm3	$2.6E^{-6}$
13.	Flexural modulus of the material, MPa	40000
14.	Flexural strength of the material, MPa	1200

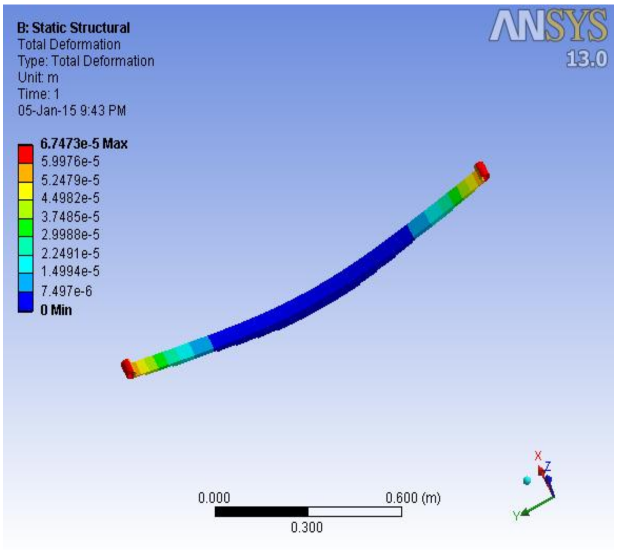
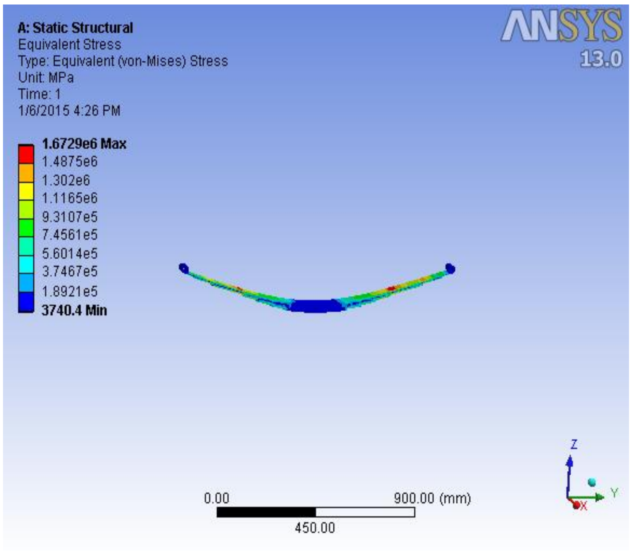
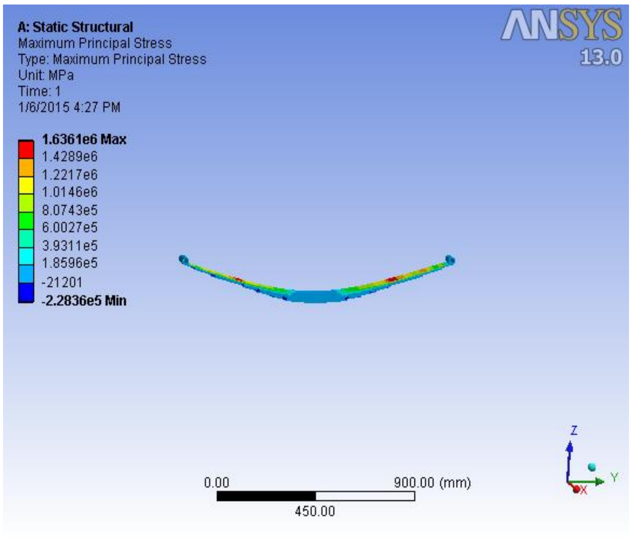


Figure 1 Results for Conventional Leaf Spring

F. ANSYS Results for Composite Leaf Spring





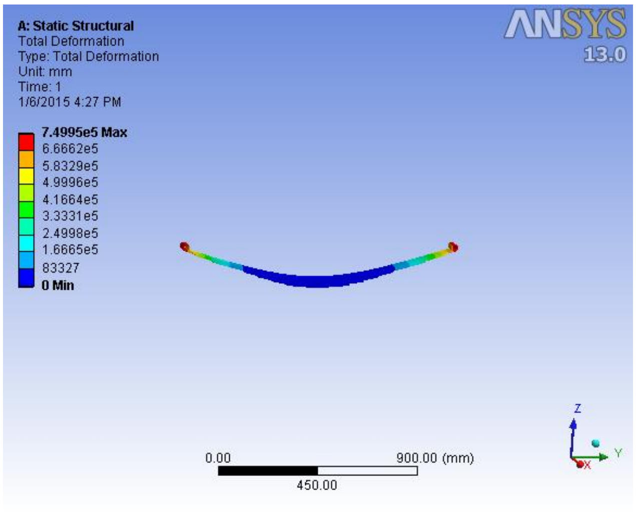


Figure 2 Results for Composite Leaf Spring

G. Results comparison

TABLE 3

COMPARISON OF DEFLECTION AND

Material	Static Load (N)	Deflection (mm)	Bending Stress (N/mm^2)
Steel	4000	198.48	940.32
E-Glass/ Epoxy	4000	180.81	911.79

STRESS

III. CONCLUSION

Under the same static load conditions deflection and stresses of steel leaf spring and composite leaf spring are found with great difference. Deflection of composite leaf spring is less as compared to steel leaf spring with the same loading condition. Bending stress is also less in composite leaf spring as compared to steel leaf spring with the same loading condition.

ACKNOWLEDGEMENT

It gives me immense pleasure in presenting a paper on “Design and analysis of mono-composite leaf spring”. This work has certainly rendered me a tremendous learning as well as practical experience.

It is my proud privilege to work under the guidance of Dr. S.P. Deshmumukh, Professor, Department of Mechanical Engineering. I am thankful to him for his precious, timely guidance and continuous inspiration throughout my M.E. course. I am thankful to him for his judgments in preparing this paper.

Finally I dedicate my study efforts to my parents, friends and the Almighty.

REFERENCES

1. Abdul Rahim Abu Talim ,Aidy Ali , G. Goudah ., Developing a Composite based elliptic spring for automotive applications., 2010,pp. 475-484.

2.Achamyeleh A Kassie, R Reji Kumar and AmrutRao,(2014),Design of Single Composite Leaf Spring for Light Weight Vehical, *International Journal of Mechanical Engineering and Robotics Research (IJMERR)*, Vol, No.1, pp 191-197.

3.E .Mahdi , O.M.S. Alkoles , A.M.S.Hamouda , B.B.Sahari., Light composite spring for vehicle suspension ., 2006 , pp.24-28.

4.Ghodake A. P., Patil K.N.,(2013)., Analysis of Steel and Composite Leaf Spring for Vehicle, *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 5*, Issue 4 (Jan. - Feb. 2013), PP 68-76.

5.GulurSiddaramanna SHIVA SHANKAR, Sambagam VIJAYARANGAN.,(2006)., Mono Composite Leaf Spring for Light Weight Vehicle – Design, End Joint Analysis and Testing., Materials Science Vol.12, pp.220-225

6.H .A .Al-Qureshi ., Automobile Leaf Spring from Composite Materials .,*Journal of Materials Processing Technology* (2001) ., pp.58-61.

7.PankajSaini, AshishGoel, Dushyant Kumar., (2013), Design and Analysis of Composite Leaf Spring for Light Vehicals., *International Journal of Innovative Research in Science, Engineering and Technology,* Vol.2, pp.1-10.

8.M.M.Patunkar, D.R.Dolas., Modelling and Analysis of Composite Leaf Spring under the Static Load Condition by using FEA., *International Journal of Mechanical and Industrial Engineering,* Vol.1, pp.1-4.

9. V Pozhilarasu1 and T ParameshwaranPillail (2013) Performance Analysis of Steel Leaf Spring With Composite Leaf Spring and Fabrication of Composite Leaf Spring., *International Journal of Engineering Research and Science & Technology*, Vol.2, No.3. pp.102-109.

