ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Performance Improvement & Weight Reduction of Mono Leaf Spring by using Composite Material

Mahesh. P. Palaskar [*1], Prof. Santosh. V. Bhaskar [2]

[*1] Senior Lecturer Department of Mechanical Engineering, SRES K.B.P. Polytechnic Kopargaon Dist- Ahmednagar ME (Design) student SRES COE Kopargaon Dist- Ahmednagar, India

[2] M.E (Design) Associate Professor & PG Co-ordinater Department of Mechanical Engineering, SRES College of Engineering Kopargaon Dist- Ahmednagar, India

palaskarmahesh5507@gmail.com

Abstract

An important parameter in the design of leaf spring is the width to thickness ratio (W/T). Decrease in W/T ratio decreases the material required & consequently the weight of the leaf spring for the same vertical load caring capacity. But at the same time this increases the stiffness and required deflection in the vertical direction may not be obtained. Deflection/stiffness is also equally important in spring design since a certain minimum required amount of deflection at a particular load is always necessary in springs, although in design of other mechanical components, deflection is undesirable within the working load range. The increase in vertical stiffness due to decrease in W/T ratio is beyond the acceptable limit due to the high value of modulus of elasticity for steel i.e. 210000 MPa[1]. But W/T ratio can be decreased without increase in vertical stiffness if some material having low value of modulus of elasticity i.e. 32500 MPa [1] is used. Reduction in vertical stiffness i.e. increase in vertical deflection range is also possible if W/T ratio is decreased within a certain limit. Hence in the present work the width to thickness ratio is decreased followed by change in material and stress analysis of a mono leaf spring is done by F.E.M. before and after changing the material. After this the values of stress at different points along the length (average values at various cross sections) after applying a point load of 2943 N [2] for both materials are compared by overlapping of graphs.

Keywords: stiffness, leaf spring, material, modulus of elasticity, stress..

Introduction

Leaf spring suspension system is the simplest cheapest and the most sturdy suspension system. Moreover the leaf spring itself acts as a link of the suspension mechanism. In addition to heavy duty vehicles, leaf springs are still used in light carriers and vehicles like Maruti Omni. The authors recommend the use of mono leaf spring in cars also as it was being used in Maruti 800 car. This is due to the better resistance offered by it to cornering & breaking forces [3]. These advantages of leaf spring can be realized better by highly improved & advanced design. For example in the present work it is proposed to use new material i.e. a composite material. The material bonded by mechanical and chemical bonds on a macroscopic scale is called as a composite material. Typical composite materials are composed of inclusions suspended in a matrix where the constituents retain their identities [4]. Reduction in weight is also achieved due to the low density 2600 Kg/m^3 [1] of composite material as compared to the high value of density of steel 7800 Kg/m^3 [1]. Such advantages can be achieved in spite of the low value of the maximum allowable stress 550 MPa [1] for the composite material as compared to the high value of maximum allowable stress 800 MPa [1] for steel. Yield strength of steel in tension being 1158 MPa [5]. It means that the strength to weight ratio [6] of composite material is higher than that of steel. This is also revealed from the Finite element analysis and the comparison of deflection obtained in case of both the materials.

Finite element analysis of leaf spring

Pro-E software is used for modeling and Abacus software for Analysis of Leaf spring.

The finite element analysis of leaf spring is to be subdivided in following steps-

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

Modeling, 2. Meshing, 3. Loads and restraints, 4. Analysis

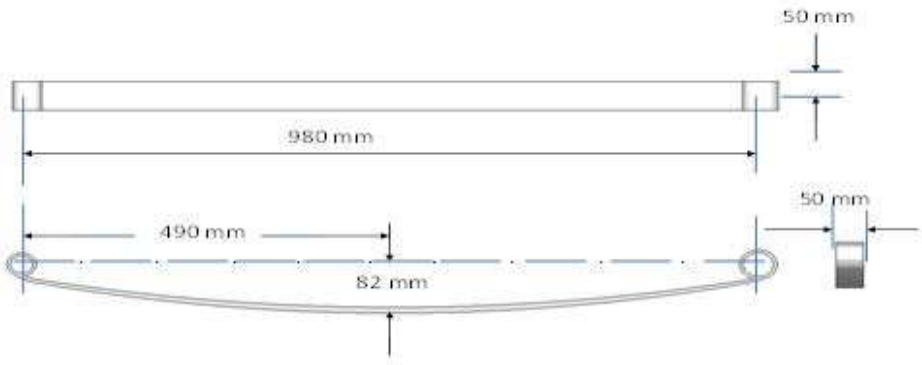


Fig.1 Geometry of Leaf Spring in AutoCAD Modeling, Mesh Generation, Loading and Boundary Conditions

By using the overall dimensions and geometry leaf spring is modeled in Pro-E software. Leaf spring is modeled in CAD software PRO-E

This leaf spring is not clamped at the center but at a distance of 425 mm from the centre of small eye since it is a non-symmetrical leaf spring. Larger eye end (right end) acts as a fixed hinge while smaller eye is shackled and acts as a movable hinge in order to accommodate the change in distance between eye centers. To represent the pivoted boundary condition at larger eye, a master node is created at the central axis of larger eye. This master node was connected to remaining nodes of eye with rigid body element RBE2. At master node all degrees of freedom except rotational DOF about y-axis were constrained. To represent the boundary condition at smaller eye, master node was created at the central axis of smaller eye. This master node was connected to remaining nodes of eye with rigid body element RBE2. At master node all DOF except rotational DOF about y-axis and translation in X direction were constrained [7]. Certain boundary conditions are required to be approximated due to limitations of F.E.M.

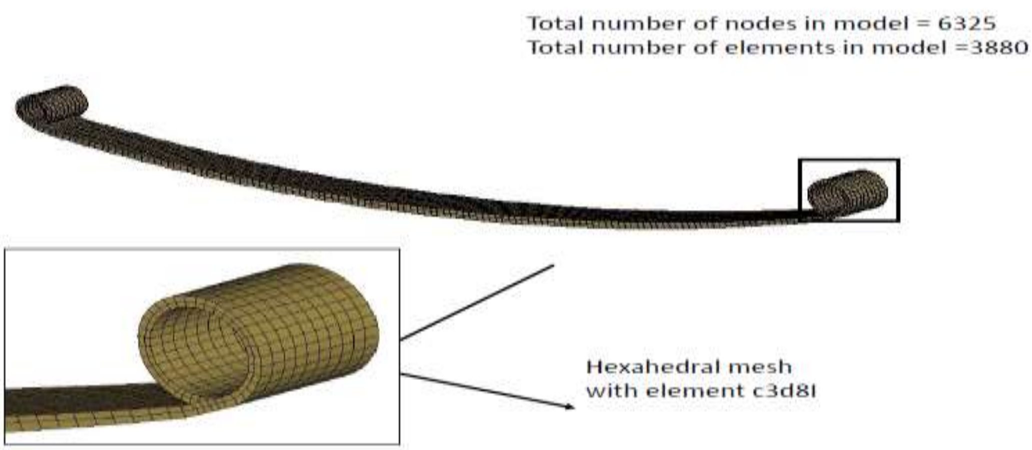


Fig. 2- Finite Element Modeling and Meshing of steel leaf spring.

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

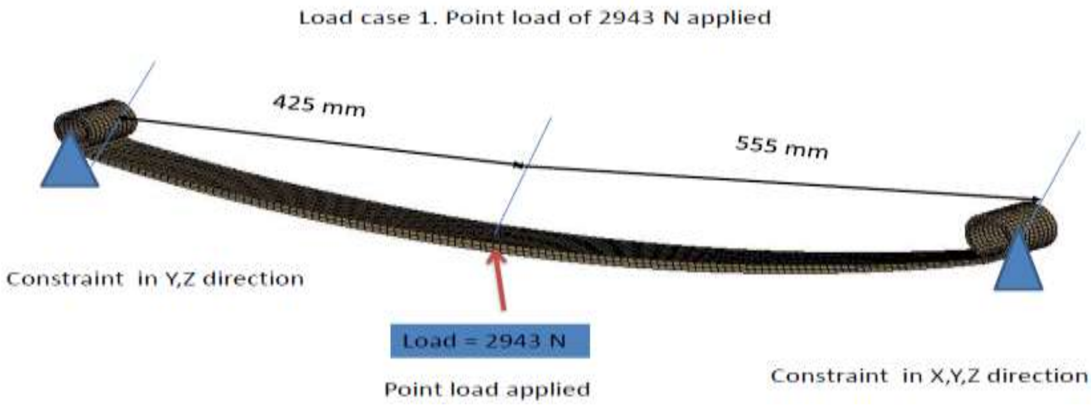


Fig. 3. Loading and Boundary Conditions

Material Properties of Leaf Springs

Card used in analysis -

*MATERIAL, NAME = steel (65Si7/SUP9) [5]

*ELASTIC, TYPE = ISOTROPIC210000.0, 0.266 , 0.0

Where - Modulus of elasticity = 210000 MPa
Poison's ratio = 0.266

Analysis Methodology

- Finite element model is prepared on CAD geometry.
- Hyper mesh software used to create mesh.
- Hexahedral mesh done on leaf spring geometry.
- Then deck is prepared
- Deck preparation steps –
  1) Apply material properties.
  2) Apply boundary conditions.
  3) Apply load.
  4) Export deck as *.inp file.
- Submit run in Abacus and obtain results odb file.
- Post process the results
- Plot deformation animation
- Plot displacement
- Plot Principal stresses.

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

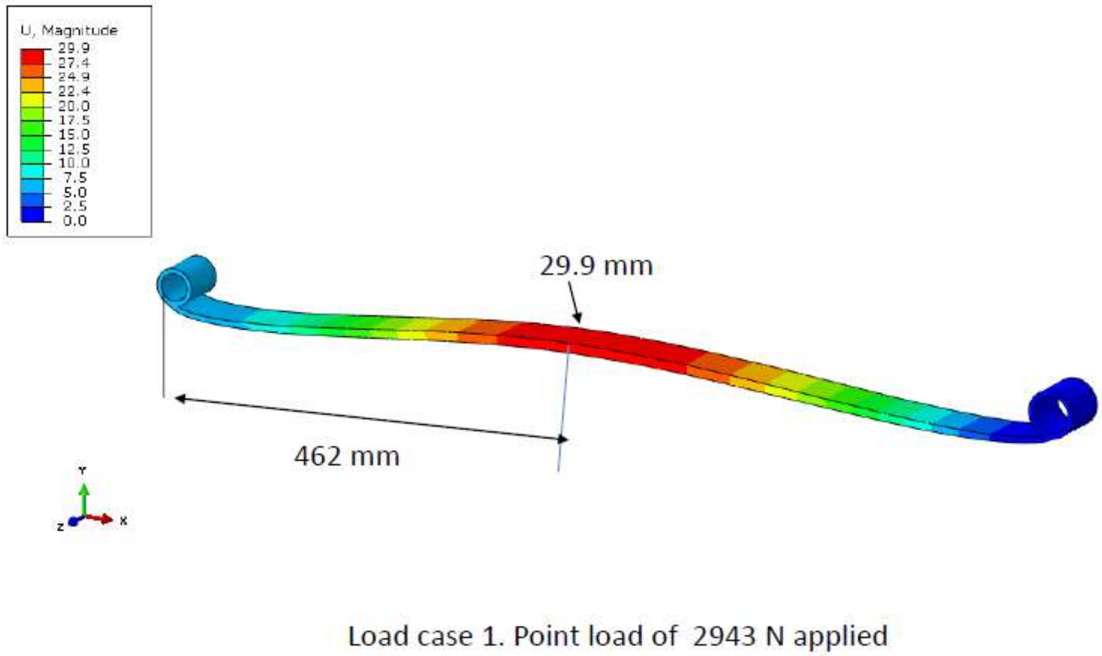


Fig. 4. Deformation shape of steel leaf spring, max displacement=29.9mm

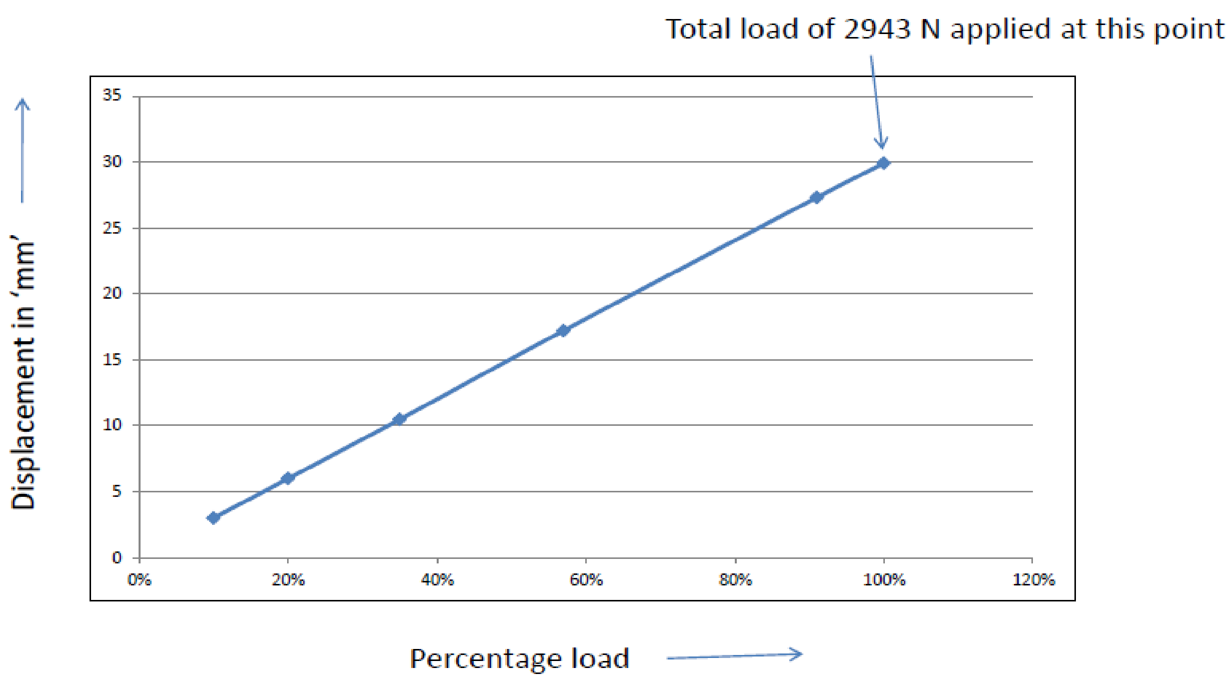
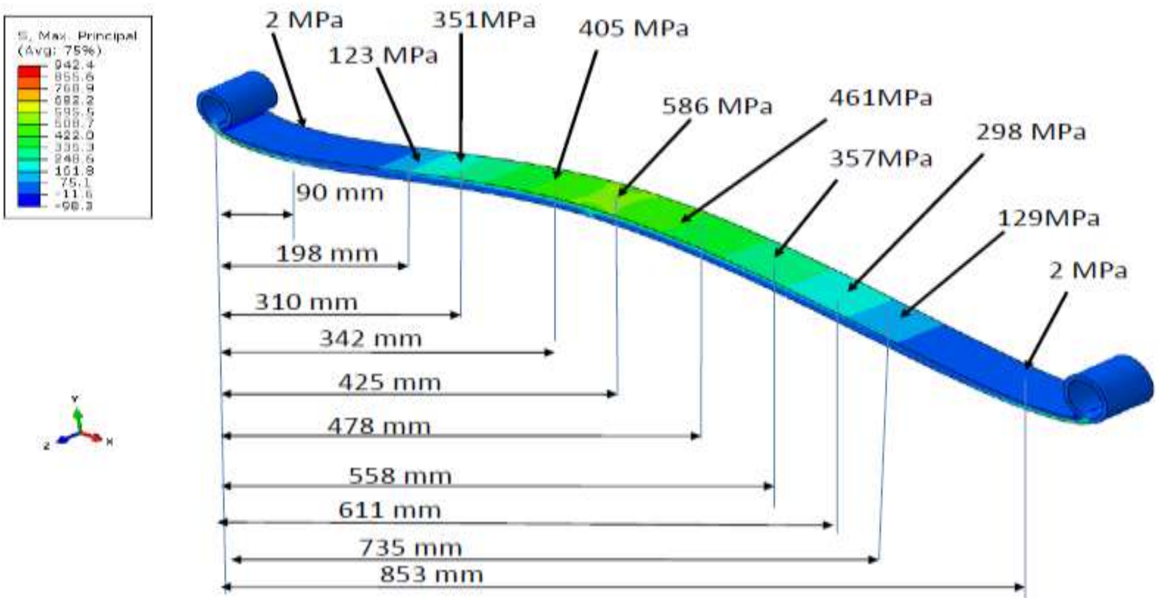


Fig. 5. Graph of Displacement v/s Percentage Load for steel leaf spring.

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852



Point load of 2943 N applied *Yield strength= 1158 MPa*

Fig. 6. Stress Contour Plot along the Length for steel leaf spring.

Table 1. Stress Variation along the length for steel leaf spring

Sr. no.	Distance of point From Left end in mm	Stress value at the point in MPa	Thickness of leaf At the point in mm
1	90	2	6.9
2	198	123	8.5
3	310	351	9.5
4	342	405	9.7
5	425	586	10.2
6	478	461	10.2
7	558	357	10
8	611	298	9.9
9	735	129	8.9
10	853	2	7.4

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

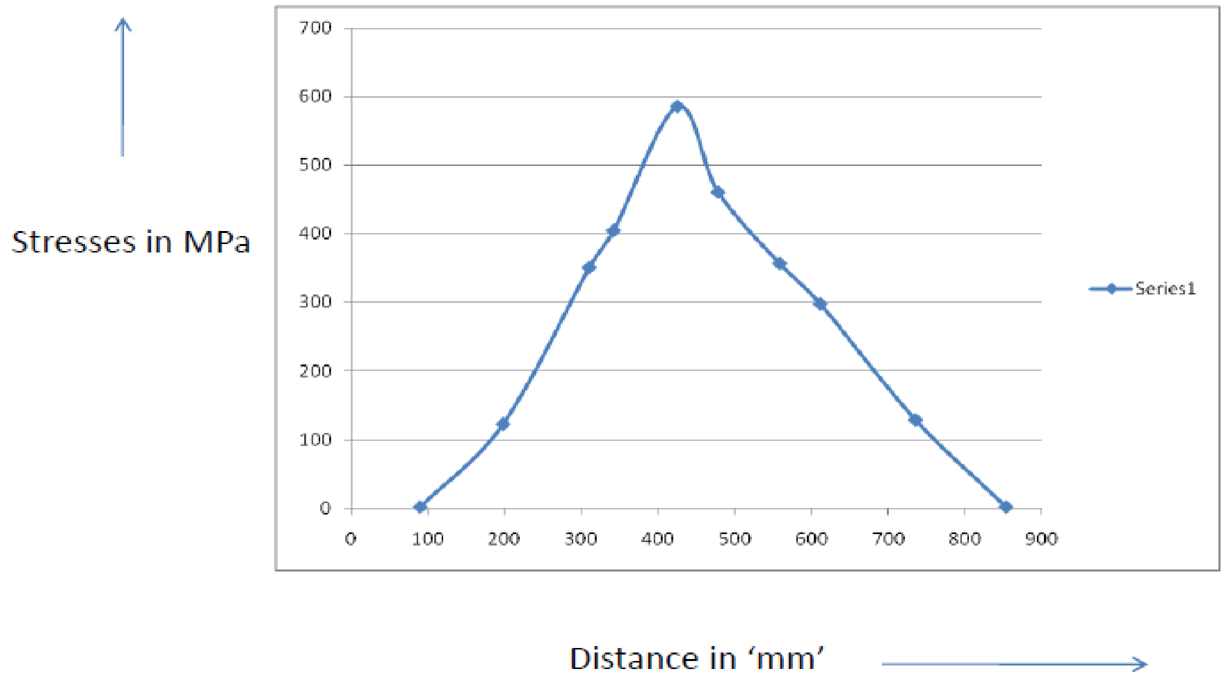


Fig. 7 Graph of Stress Distribution along the Length for steel leaf spring

Investigation of epoxy resin as material for leaf spring design theory

While considering the optimization of leaf spring it is observed that if we try to reduce the material by increasing the thickness and decreasing the width of the leaf spring, although weight reduction is possible without compromise in the strength in terms of its capacity to resist vertical bump loads, but this increases the stiffness of the leaf spring, decreasing the deflection. This reduces the capacity of the spring to absorb the shocks and hence the comfort of the drive decreases. This is due to the high value of modulus of elasticity of steel EN47A, i.e. 210000 MPa [1]. If we can have some material having low modulus of elasticity, as low as 325000 MPa [1], we can considerably increase the value of thickness as compared to the width of the leaf spring while maintaining the required deflection at lower loads also.

Properties of Composite Material (Epoxy Resin)

SR. NO	PROPERTY	UNIT	VALUE
1	Modulus of elasticity	MPa	32500
2	Max. allowable stress	MPa	550
3	Mass density	Kg/m^3	2600
4	Poission's ratio	---	0.217
5			

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

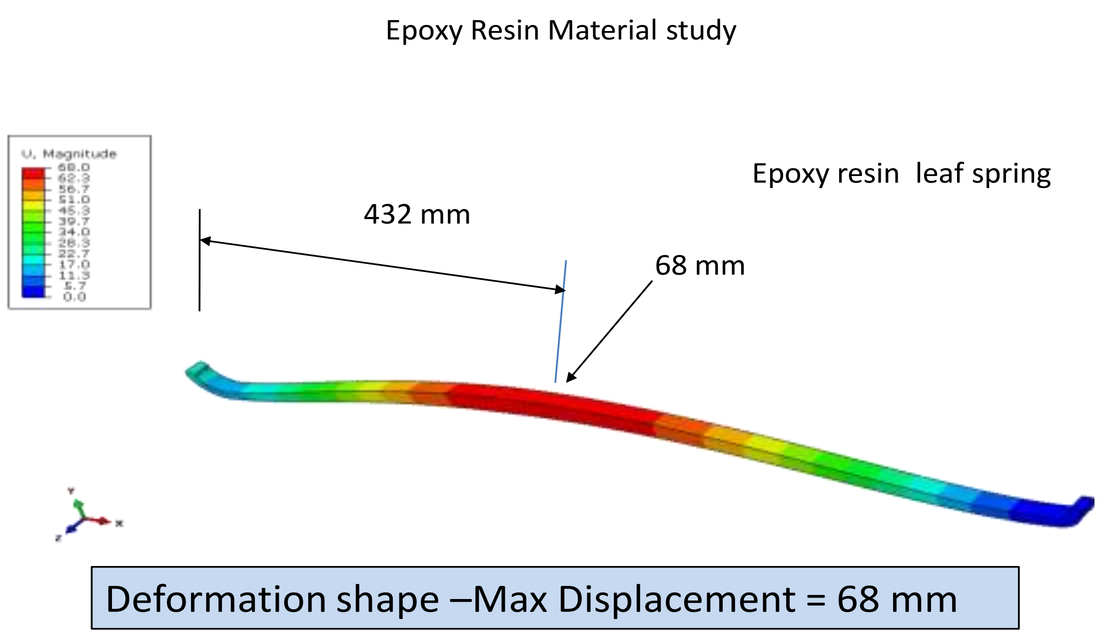


Fig. 8 Deformation of composite leaf spring with linear variation in thickness

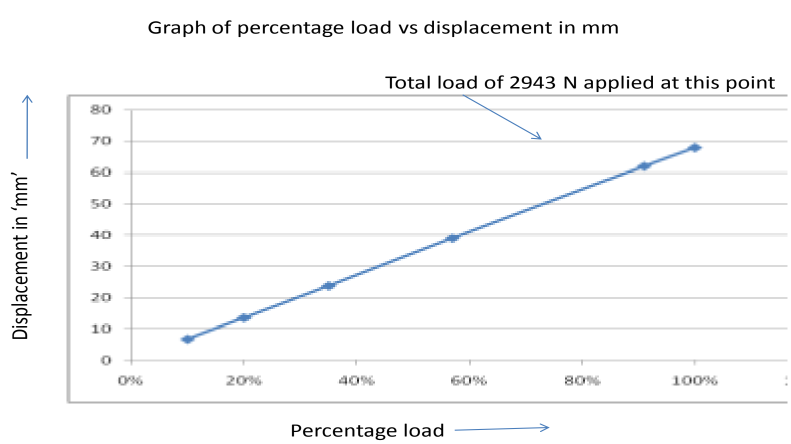


Fig. 9 Graph of deflection v/s percentage load
for composite leaf spring with linear variation in thickness

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

Stress contour plots- Epoxy resin leaf spring

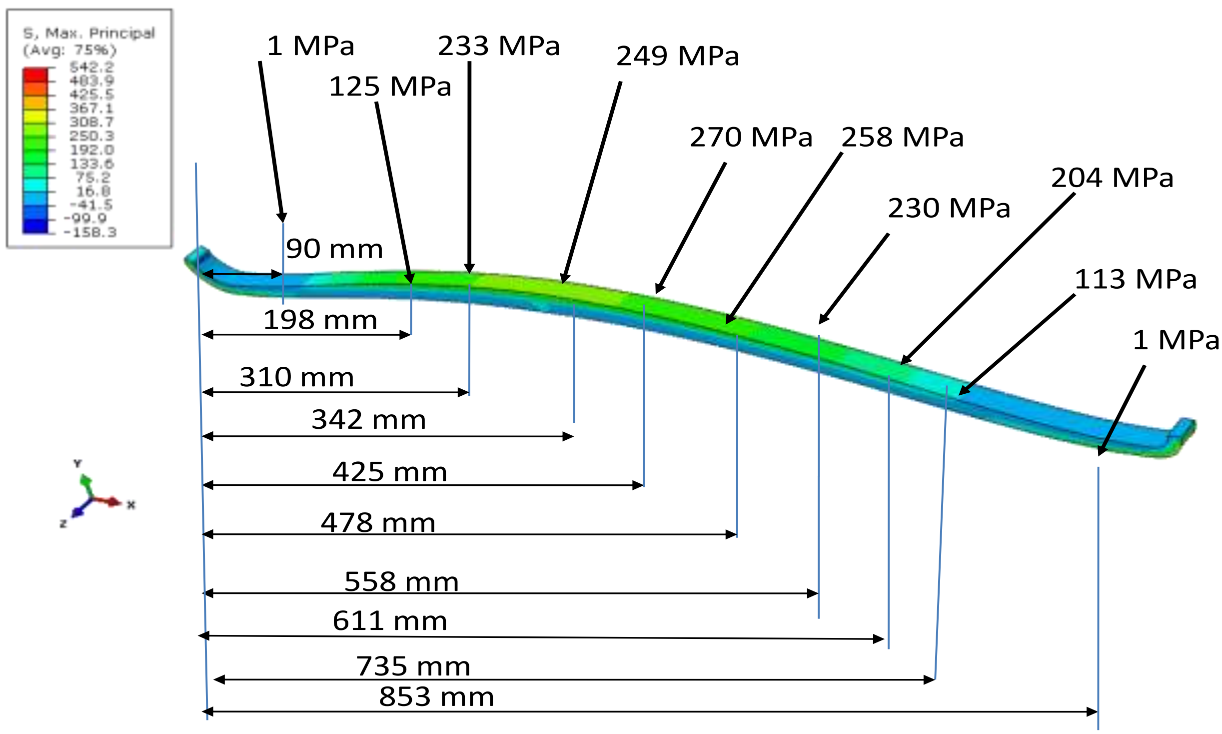


Fig.10 Stress values for composite leaf spring with linear variation in thickness

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

TABLE 2 Stress variation

Table stress along the length for Epoxy resin leaf spring			
Sr. no.	Distance of point From Left end In mm	Stress value at the point in MPa	Thickness of leaf At the point in mm
1	90	1	13.8
2	198	125	16.9
3	310	233	20
4	342	249	21.1
5	425	270	21.15
6	478	258	20.32
7	558	230	18.7
8	611	204	17.8
9	735	113	15.2
10	853	1	12.7

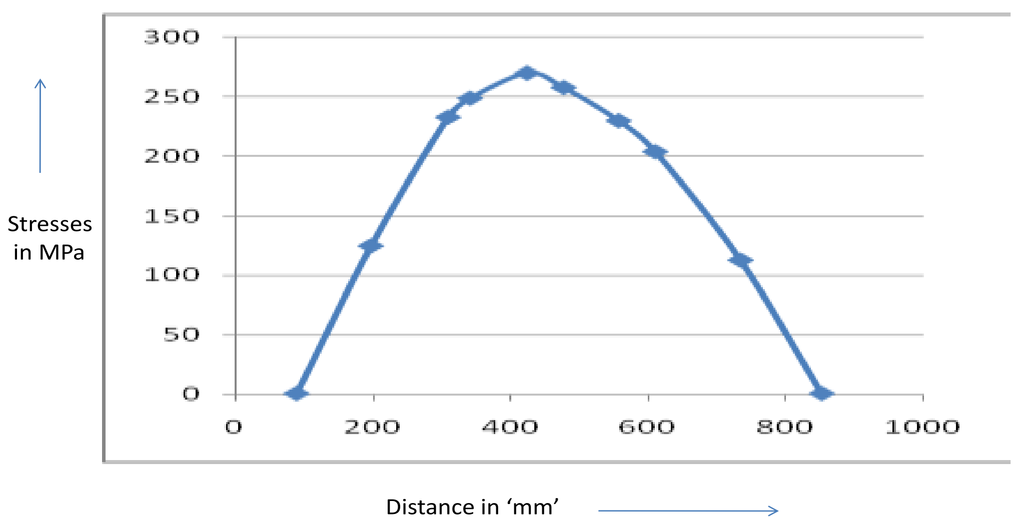


Fig. 11 Graph of Stress Distribution along the Length for composite leaf spring

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

Table 3 - Results of change in material of Spring

Sr. no.	Parameter	Value for Steel	Value for Epoxy Resin	Percentage Improvement
1	Maximum stress value in MPa	586	270	53.92
2	Volume Of springs in mm^3	484975	387633	20.07
3	Mass of springs in kg	3.789	1.008	73.4
4	Maximum deflection (deflection at max load).	29.9	68	127.4

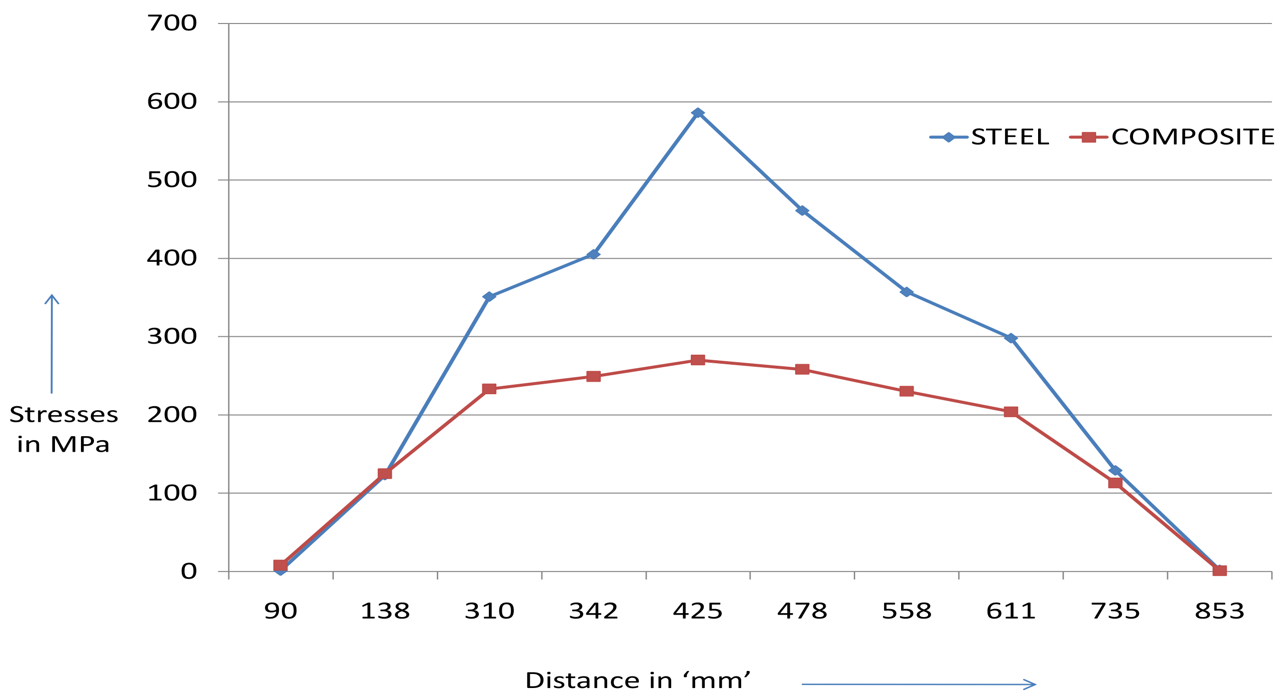


Fig. 12 Distribution of stress along the length.
(Graphical comparison between steel and composite material)

Results and discussion

1. In spite of only 20.07 % saving in material by volume, we have 73.4 % saving in material by mass due to the reduced density of composite material as compared to steel.
2. Distribution of stress is better (more uniform) if composite material is used.

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

3. Utilization of material is improved by changing the material from steel to composite.
4. A considerable reduction in the stress values is observed by replacing steel by epoxy resin.
5. The reduction in maximum stress is 53.92 %. This value is safe even though the maximum allowable stress for epoxy resin is much lower than steel.

Conclusion

Material saving up to 73.40 % can be achieved by shifting to new/composite material.

By shifting to new material volume of leaf spring is be reduced by 20.07 %.

In other words distribution of stress is improved (it becomes more uniform) by using new material. Utilization of material is improved by shifting to new material.

Riding comfort of passengers is improved due to reduction in unspung mass of the vehicle by shifting to new material. Deflection is also improved by 127.4 % by shifting to new material i.e. epoxy resin due to reduction in stiffness. This results in added increase in the riding comfort.

Acknowledgement

It gives me a great pleasure to express my deep sense of gratitude towards my project guide and ME Coordinator Prof. S.V. Bhaskar for his valuable guidance and motivation from time to time for the completion of this work.

At the same time it delights me a lot to extend my sincere and profound gratitude towards Prof. Dr. A.G. Thakur HOD (Mechanical) and Vice Principal for his constant encouragement and valuable directions in due course of completion of the work.

I am greatly inspired by Principal COE Kopargaon Prof. Dr. D.N. Kyatanavar and I am constantly supported by Principal KBP Polytechnic Prof. R. A. Kapgate for which I express my deep sense of gratitude to both of them.

References

1. *Rajendran, S. Vijayarangan "Optimal design of a composite leaf spring using genetic algorithms", 'Computers and Structures' 2001,7.,79., pp. 1121-1129.*
2. *K.K. Jadhao and Dr. R.S.Dalu, "Experimental Investigation and Numerical analysis of composite leaf-spring", 'International Journal of Engineering Science and Technology' 2011,3.,6., pp. 4759 to 24764.*
3. *Dr. Kirpal Singh, "Automobile Engineering" , 'Standard Publishers Distributers'. 2011,1., pp 168-175.*
4. *M. Venkatesan, D. Helmen Devraj, "Design and Analysis of Composite Leaf Spring in Light Vehicle", 'International Journal of Modern Engineering Research (IJMER)'. 2012,2., 2249-6645 pp-213-128.*
5. *Kumar Krishan and Agrawal M.L., "A Finite Element Approach for Analysis of a Multi Leaf Spring Using CAE Tools", 'Research Journal of Recent Sciences', 2012, 1.,2., pp. 92 to 96.*
6. *Jadhav Mahesh V, Zoman Digambar B, Y.R. Kharde, R.R. Kharde, "Performance Analysis of Two Mono Leaf Spring Used for Maruti 800 Vehicle ,'International Journal of Innovative Technology and Exploring Engineering', 2012,2.,1.,pp.65 to 67*
7. *V.K.Aher, R.A.Gujar, J,P,Wagh & P.M.Sonawane, "Fatigue Life Prediction of Multi Leaf Spring used in the Suspension System of Light Commercial Vehicle", 'International Journal on Theoritical & Applied Reaserch in Mechanical Engineering (IJTARME)' 2012,1.,1., pp. 71 to 77.*