Modeling and Analysis of a Hybrid Mono-Leaf Spring Using FEA

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Abstract- Weight reduction is now the main issue in automobile industries. 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, which is considered to be the mass not supported by the leaf spring. Since the composite materials have more elastic strain energy storage capacity and high strength-to-weight ratio as compared to those of steel, Composite material is taken into consideration. The modeling of the mono leaf spring is done in Creo Parametric 2.0 and the analysis is carried out in Ansys 15.0. The project is carried out with hybrid mono leaf spring is taken in such a way that the 5 layers and 7 layers of the composite layers are placed in between the steel layers in the ends.

Index Terms- Creo parametric 2.0, design optimization, weight reduction, hybrid.

I. INTRODUCTION

A leaf spring is a simple form of spring commonly used for the suspension in wheeled vehicles. Originally called a laminated or carriage spring, and sometimes referred to as a semi-elliptical spring or cart spring, it is one of the oldest forms of springing, dating back to medieval times.

A leaf spring takes the form of a slender arc-shaped length of spring steel of rectangular cross-section. The center of the arc provides location for the axle, while tie holes are provided at either end for attaching to the vehicle body. For very heavy vehicles, a leaf spring can be made from several leaves stacked on top of each other in several layers, often with progressively shorter leaves. Leaf springs can serve locating and to some extent damping as well as springing functions. While the interleaf friction provides a damping action, it is not well controlled and results in stiction in the motion of the suspension. For this reason some manufacturers have used mono-leaf springs.

In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturer in the present scenario. 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, which is considered to be the mass not supported by the leaf spring.

The introduction of composite materials has made it possible to reduce the weight of the leaf spring without any reduction on load carrying capacity and stiffness. So, composite materials are now used in automobile industries to take place of metal parts. So, composite materials are now used in automobile industries to take place of metal parts. Since the composite materials have more elastic strain energy storage capacity and high strength-to-weight ratio as compared to those of steel. Composite materials offers opportunity for substantial weight saving. Springs are design to absorb & store energy & then release it hence strain energy of material and shape becomes major factors in designing the spring.

II. PROBLEM IDENTIFICATION

The behaviour of steel leaf spring is non linear, relatively high weight, and change in solid axle angle due to weight transfer specially during cornering of vehicle, that will lead to over steer and directional instability under such situation it is very difficult for driver to control vehicle, (defect of metallic leaf spring).

So considering automobile development and importance of relative aspect such as fuel consumption, weight, riding quality, and handling, hence development of new material is necessary in the automobile industry.

Recently, graphite and carbon fiber demonstrate its superiority over other composite material however due to cost and availability limitation the present work restricted to leaf spring made up of glass fiber, and Epoxy resin (general purpose resin).

Many papers were devoted to find spring geometry. The recently vehicle such as Ford, and Volvo buses are using leaf spring made up of carbon fiber as it gives good advantage but costly. So in this, we selected glass fiber and general purpose resin for spring
material on the basis of cost factor and strength. The material would be a combination of steel on either side with the composite materials in between the closed layers.

III. MODELING OF MONO LEAF SPRING

The modeling of the leaf spring is done in Creo Parametric 2.0.

Introduction to Creo Parametric:

Creo Parametric is a computer graphics system for modeling various mechanical designs and for performing related design and manufacturing operations. The system uses a 3D solid modeling system as the core, and applies the feature-based, parametric modeling method. In short, Creo Parametric is a feature-based, parametric solid modeling system with many extended design and manufacturing applications.

Creo Parametric is the first commercial CAD system entirely based upon the feature-based design and parametric modeling philosophy. Today many software producers have recognized the advantage of this approach and started to shift their product onto this platform.

Creo Parametric was designed to begin where the design engineer begins with features and design criteria. Creo Parametric's cascading menus flow in an intuitive manner, providing logical choices and pre-selecting most common options, in addition to short menu descriptions and full on-line help. This makes it simple to learn and utilize even for the most casual user. Expert users employ Creo Parametric's "map keys" to combine frequently used commands along with customized menus to exponentially increase their speed in use. Because Creo Parametric provides the ability to sketch directly on the solid model, feature placement is simple and accurate.

The model is as shown in the figure 1 as shown below:

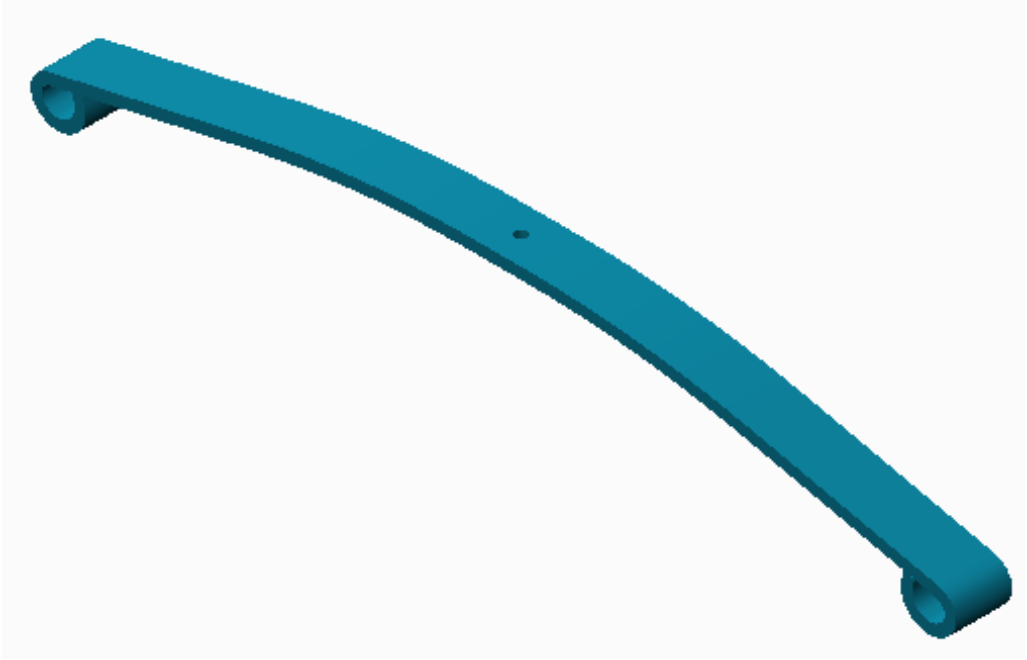


Fig 1. Mono Leaf Spring Model

The drawing Specifications taken are as shown in the Figure 2 below:

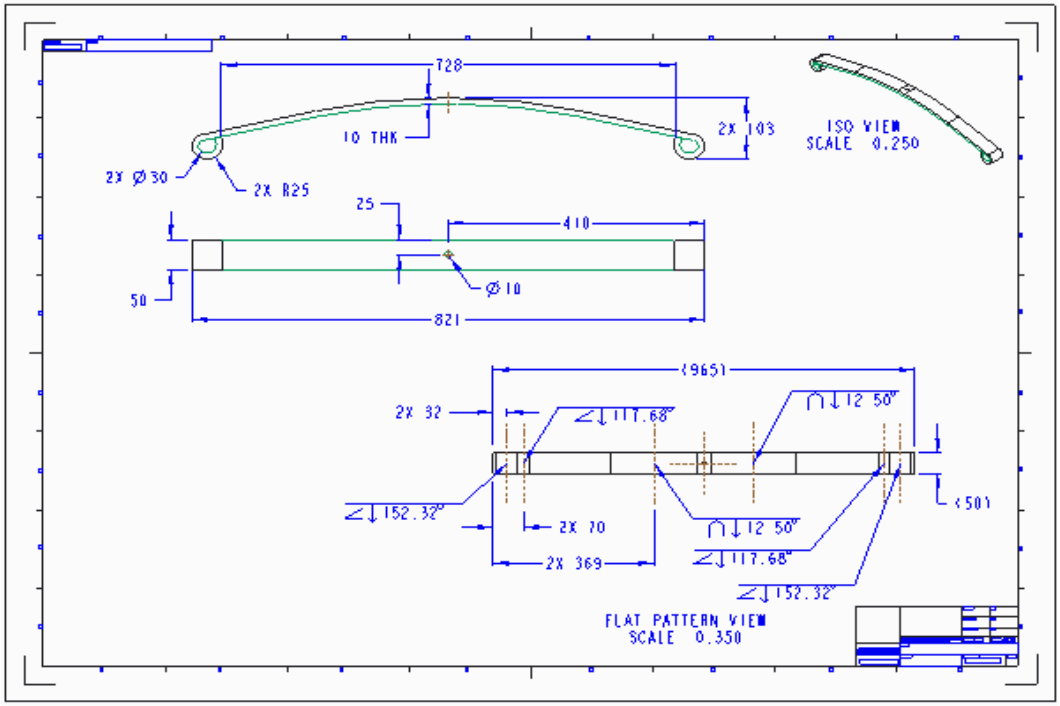


Fig. 2 Drawing Specifications for the Mono Leaf Spring.

IV. ANALYSIS OF MONO LEAF SPRING

The analysis of the mono leaf spring is done in Ansys 15.0 and the analysis reports are as shown below.

The geometry and the mesh model in Ansys are as shown in the Fig.3 and Fig. 4 below respectively.

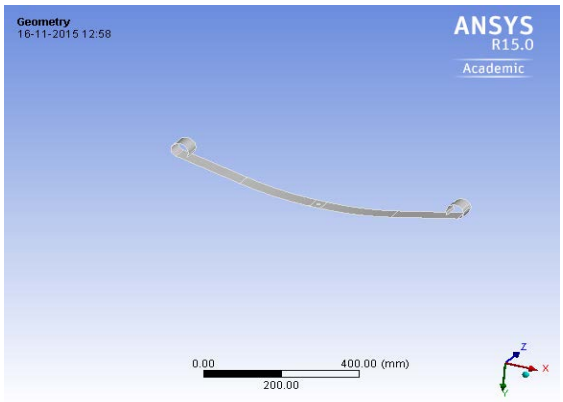


Fig. 3 Geometry of the mono leaf spring

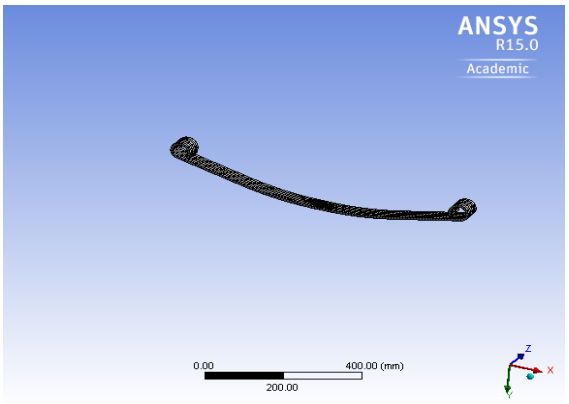


Fig. 4 Mesh of the mono leaf spring

The analysis is carried out for the Steel material and the composite material for the mono leaf spring.

Analysis of Steel mono leaf spring:

The Boundary Conditions are given as the force of 250N and fixed at the centre of the spring. The deformation and Equivalent Stress reports for the steel mono leaf springs are are as shown in the Fig. 5 and Fig. 6 respectively.

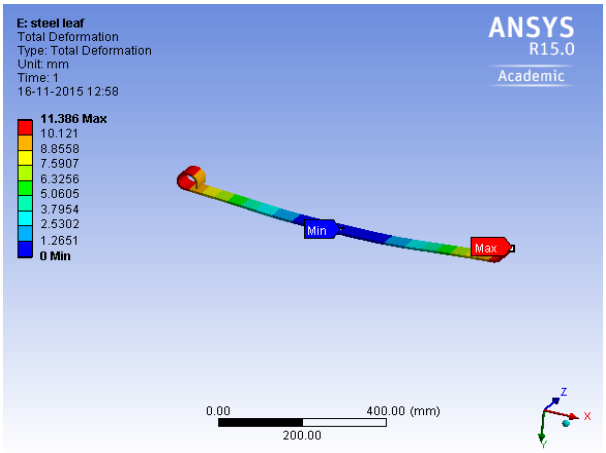


Fig. 5 Deformation of the Steel mono leaf spring

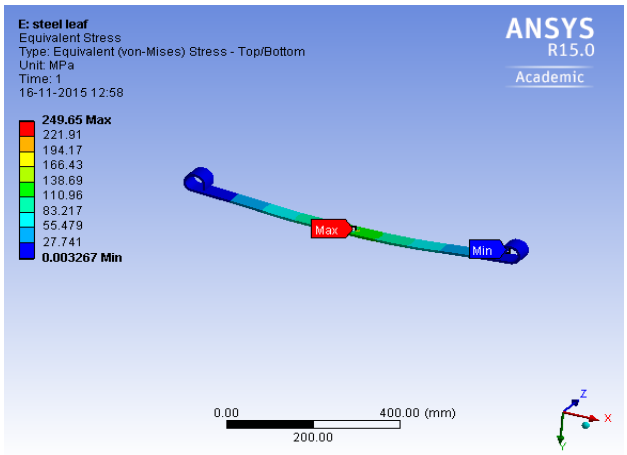


Fig.6 Equivalent Stress of the Steel mono Leaf spring

The deformation and Equivalent Stress reports for the composite mono leaf springs are are as shown in the Fig. 7 and Fig. 8 respectively.

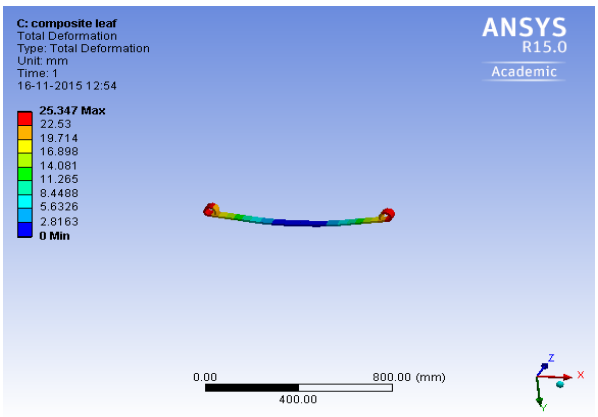


Fig. 7 Deformation of the Steel mono leaf spring

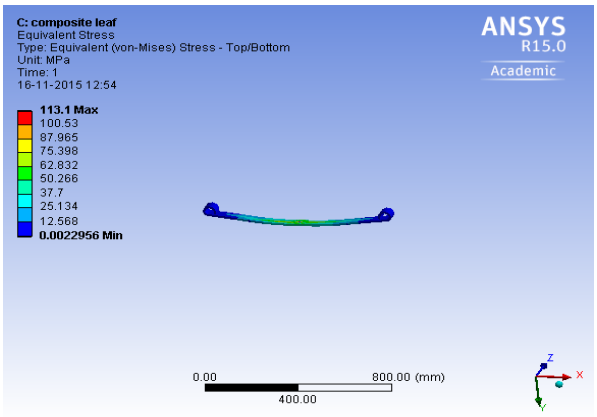
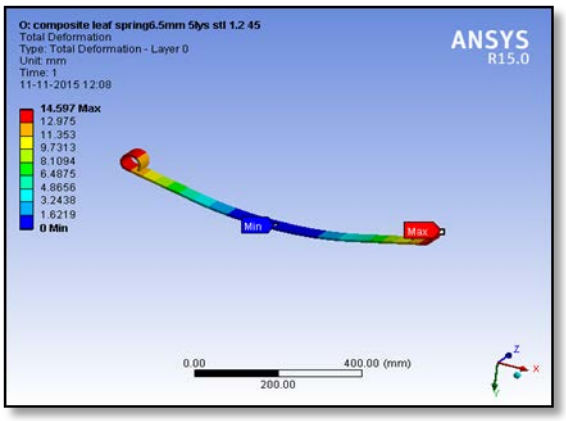


Fig.8 Equivalent Stress of the Steel mono Leaf spring

Also the analysis is carried out for the leaf spring which consists of steel material on the either sides with the composite material placed in 5 layers and 7 layers in between the steel. The deformation of and the Equivalent Stress reports for the hybrid mono leaf spring are shown in the Fig. 9 and Fig. 10 respectively.



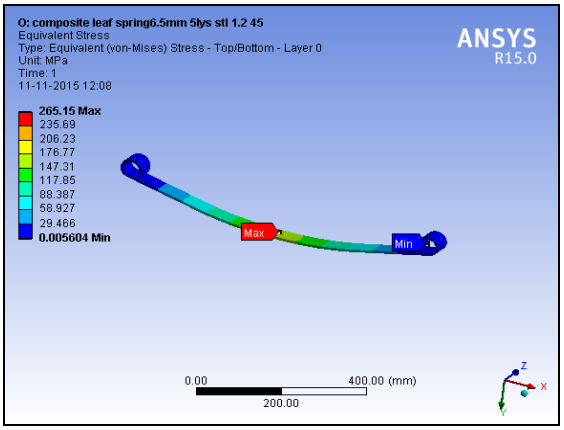


Fig. 9 Deformation of the hybrid mono leaf spring Fig.10 Equivalent Stress of the hybrid mono Leaf spring

The layers for the above result are as shown in the Table 1 below.

Table 1. Material layer seperation specifications considered for the hybrid mono leaf spring for 5 layers

Layer	Material	Thickness (mm)	Angle (°)
(+Z)			
7	Structural Steel	1.2	0
6	sglass epoxy	0.82	0
5	sglass epoxy	0.82	45
4	sglass epoxy	0.82	0
3	sglass epoxy	0.82	-45
2	sglass epoxy	0.82	0
1	Structural Steel	1.2	0
(-Z)			

The frequencies obtained through different mode shapes are as shown in the Table 2 below:

Table 2. Frequencies for Different Mode shapes

	Mode	Frequency [Hz]
1	1.	26.525
2	2.	27.326
3	3.	92.642
4	4.	118.87
5	5.	180.34
6	6.	186.42

The 7 layers for the above condition are as shown in the Table 3 below.

Table 3. Material layer seperation specifications considered for the hybrid mono leaf spring for 7 layers

Layer	Material	Thickness (mm)	Angle (°)
(+Z)			
9	Structural Steel	1.2	0
8	sglass epoxy	0.5857	0
7	sglass epoxy	0.5857	45
6	sglass epoxy	0.5857	0
5	sglass epoxy	0.5857	-45
4	sglass epoxy	0.5857	0
3	sglass epoxy	0.5857	45
2	sglass epoxy	0.5857	0
1	Structural Steel	1.2	0
(-Z)			

V. RESULTS AND DISCUSSION

The analysis of Steel Mono Leaf spring with the composite mono leaf spring is done. In addition we would like to change the orientation of composite leaf springs in such a way that the thickness varies from 1.2mm, 1.3mm and 1.5mm with 5 and 7 layers of composite allowed with an angle of 45^0,55^0,65^0,75^0 and 90^0.

The results for the composite leaf spring of 6.5mm with 7 layers and steel thickness of 1.2mm and different angles are as shown below:

RESULTS	**45 degrees**	**55 degrees**	**65 degrees**	**75 degrees**	**90 degrees**
TOTAL DEFORMATION (mm)	14.596	14.567	14.52	14.472	14.433
STRAIN	0.0013371	0.0013382	0.0013380	0.0013368	0.0013346
STRESS (Mpa)	264.38	264.6	264.55	264.32	263.88
WEIGHT (Kg)	1.393	1.393	1.393	1.393	1.393

The results for the composite leaf spring of 6.5mm with 7 layers and steel thickness of 1.5 mm and different angles are as shown below:

RESULTS	**45 degrees**	**55 degrees**	**65 degrees**	**75 degrees**	**90 degrees**
TOTAL DEFORMATION (mm)	13.219	13.204	13.180	13.155	13.136
STRAIN	0.0012159	0.0012165	0.0012164	0.0012158	0.0012146

STRESS (Mpa)	240.42	240.53	240.51	240.39	240.17
WEIGHT (Kg)	1.5738	1.5738	1.5738	1.5738	1.5738

VI. CONCLUSION

This project work involves the comparison of conventional EN and Composite material leaf spring under static loading conditions the model is preferred of in Creo Parametric 2.0 and then analysis is perform through ANSYS 15.0 from the result obtained it will be concluded that the development of a composite mono leaf spring having constant cross sectional area, where the stress level at any station in the leaf spring is considered constant due to the parabolic type of the thickness of the spring, has proved to be very effective. The analysis of taking 5 layers and 7 layers composite in the middle of the leaf springs are obtaining good possible results. The analysis of 5 layers composite hybrid leaf spring can be taken taking weight into consideration.

REFERENCES

[1] B.Vijaya Lakshmi, I. Satyanarayana, “Static And Dynamic Analysis On Composite Leaf Spring In Heavy Vehicle”, International Journal of Advanced Engineering Research and Studies, Vol. II/ Issue I/Oct.-Dec.,2012/80-84.

[2] T.N.V.Ashok Kumar, E.Venkateswara Rao, S.V.Gopal Krishna, “Design and Material Optimization of Heavy Vehicle Leaf Spring”, IJRMET Vol. 4, Issue Spl - 1, Nov 2013- Apri l 2014.

[3] Manjunath H.N, Manjunath.K, T.Rangaswamy, “Static Analysis and Fatigue Life prediction of Composite Leaf Spring for a Light Commercial Vehicle (TATA ACE)”, International Journal of Engineering Research, Volume No.3, Issue No.7, pp : 422-425

[4] Avani B. Londhe, “FEA and Analytical Analysis of Natural Fibers Composite Leaf Spring”, International Journal of Mechanical Engineering and Research, ISSN No. 2249-0019, Volume 3, Number 4 (2013), pp. 355-360.

[5] Parkhe Ravindra, Mhaske Raman, Belkar Sanjay, “Modeling and Analysis of Carbon Fiber Epoxy Based Leaf Spring under the Static Load Condition by Using FEA”, International Journal of Emerging Science and Engineering (IJESE), ISSN: 2319–6378, Volume-2, Issue-4, February 2014.

[6] Sebastian John, Jana Ehlig, “Development of an adaptive composite leaf spring”, Inter-noise 2014.

[7] R M PatilÀ, S M Hatrote, A K Pharale, V S Patil, G V Chiniwalar and A S Reddy, “Fabrication and Testing of Composite Leaf Spring for Light Passenger Vehicle”, International Journal of Current Engineering and Technology, ISSN 2277 – 4106.

[8] M. Raghavedra, Syed Altaf Hussain, V. Pandurangadu, K. PalaniKumar, “Modeling and Analysis of Laminated Composite Leaf Spring under the Static Load Condition by using FEA”, International Journal of Modern Engineering Research (IJMER), Vol.2, Issue.4, July-Aug. 2012 pp-1875-1879

[9] Pankaj Saini, Ashish Goel, Dushyant Kumar, “Design And Analysis Of Composite Leaf Spring For Light Vehicles”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 5, May 2013.

[10] Gulur Siddaramanna Shiva Shankar, Sambagam Vijayarangan, “Mono Composite Leaf Spring for Light Weight Vehicle – Design, End Joint Analysis and Testing”, Issn 1392–1320 Materials Science (Medžiagotyra). Vol. 12, No. 3. 2006

[11] R D V Prasad, R.Sai Srinu , P.Venkata rao, “Design & Analysis of Mono Composite Leaf Spring”, International Journal of Scientific Research Engineering & Technology (IJSRET), Volume 2 Issue2 pp 103-107 May 2013.

[12] 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 & Industrial Engineering, Volume 1 Issue 1-2011.

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