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# Stress Analysis of a Mono-parabolic Leaf Spring–A Review

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***Abstract:*** *This work has been carried out on a mono parabolic leaf spring of a Maruti Omni Car. This paper describes design and experimental analysis of a conventional parabolic leaf and suggested composite material leaf spring .The composites used are HM and HS Carbon polymers .Finite Element analysis (FEA) is carried out at static condition of the spring model so that stress distribution can be observed for analysis of high stress zones. CAD model is prepared in Pro-E .The analysis has been observed for various loading conditions and the overall stress distribution zones have been studied. The objective is to compare the load carrying capacity, stiffness and weight savings of composite parabolic leaf spring with that of a conventional steel leaf spring .The design constraints are stresses and deflections induced during various loading conditions.*

***Keywords:*** *Leaf springs, Composites, HS Carbon, HM Carbon, FEM Simulation, Mono-parabolic leaf springs*

## I. INTRODUCTION

A leaf spring is mostly used in suspension of the wheeled vehicles. It is also referred as semi-elliptical leaf spring and forms an arc shape .The center of the arc is positioned and fixed on the on the axle. A leaf spring can either be attached directly to the frame at both ends or attached directly at one end, usually the front, with the other end attached through a shackle, a short swinging arm. The shackle takes up the tendency of the leaf spring to elongate when compressed and thus makes for softer springiness. There is almost a direct proportionality between the weight of the vehicle and its fuel consumption. This paper is mainly focused on the implementation of composite materials by replacing steel in conventional leaf springs of a suspension system. Automobile-sector is showing an increased interest in the area the introduction of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. The contents of each section may be provided to understand easily about the paper. of composite material-leaf springs due to their high strength to weight ratio. Therefore analysis of composite material leaf springs has become essential in showing the comparative results with conventional leaf springs.

In this analysis the conventional steel leaf spring is tested for static load condition and results are compared with a virtual model of composite material leaf spring. Leaf spring is modeled in Pro-E 5.0 CAD software and it is imported and simulated in ANSYS 10.0 for better understanding. Results of Composite Leaf Spring are compared on the basis of analysis reports produced by ANSYS software. The material used for conventional steel leaf spring is EN45 and for composite leaf spring HS Carbon and HM Carbon material is used.

## II. LITERATURE SURVEY

We know that composite materials have more elastic strain energy storage capacity and high strength-to-weight ratio as compared to the conventional steel. With use of composite materials the weight of the leaf spring without any reduction on load carrying capacity and stiffness can be achieved. Therefore analysis of composite material leaf springs has become essential in showing the comparative results with conventional leaf springs.(1,2) I. Rajendran, S. Vijayarangan presented a formulation & solution technique using genetic algorithms for design optimization of composite leaf springs. . (3)By using the results of conventional leaf spring Mahmood M. Shokrieh, Davood designed and optimized composite one made from fiberglass with epoxy resin using ANSYS. Main consideration was given to the optimization of the spring geometry.(4) Mouleeswaran Senthil Kumar describes static and fatigue analysis of steel leaf spring and composite multi leaf spring made up of glass fibre reinforced polymer using life data analysis.(5 )M.Venkatesan ,D .Helmen Devaraj in their work have compared the load carrying capacity of steel and composite material by giving design constraints.(6) M.Raghvedra ,Syed Altaf Hussain ,V.Pandurangadu, K.Palani Kumar have used laminated composites as a replacement to conventional steel and have studied the three composites subjected to the loads.Material properties of composite structures have been reported in many literature works .Recently emphasis is been given on mass reduction and development of alternate materials and processing technology in the vehicle equipment manufacturing industry.

## III. METHODOLGY

In this paper, a comparative analysis of virtual model of conventional steel leaf spring is done with a virtual model of a composite leaf spring under static load condition. Varying loads are applied and the results have been studied for various loading condition. Two eye ends are fixed and loads have been applied at the center of the arc in upward direction .The spring is loaded maximum load of 1200N is applied to all the three materials .Further loads of 800N and 400N are applied subsequently and the values are studied .A static analysis determines stresses, strains, displacements and forces in the structure .

The parameters like material properties, loading conditions, support conditions are specified for the pre-processing analysis. The boundary conditions are applied by taking into consideration experimental loading conditions.

## IV. CHARACTERISTICS OF COMPOSITES

A composite material is defined as a material composed of two or more constituents combined on a macroscopic scale by mechanical and chemical bonds. Typical composite materials are composed of inclusions suspended in a matrix. The constituents have the characteristic to retain their identities in the composite. Many composite materials offer properties which is a combination of strength and modulus that are either comparable to or better than any traditional metallic materials.

Composites have low specific gravities, the strength weight-ratio and modulus weight-ratios of these composite materials are markedly superior to those of metallic materials. As a result of so many advantages composites have emerged as a major class of structural material and are either used or being considered as substitutions for metal in many weight-critical components in aerospace, automotive and other industries. These materials also offer high internal damping which leads to better vibration energy absorption within the material and results in reduced transmission of noise land vibration to

## V. SPECIFICATIONS OF CONVENTIONAL LEAF SPRINGS USED IN MARUTI OMNI

Conventional steel leaf springs are manufactured by EN45, 60Si7, EN47, 50Cr4V2, 55SiCr7 and 50CrMoCV4 etc. These materials are widely used for production of the parabolic leaf springs and conventional multi leaf springs .The material used for Maruti Omni Is EN45.

The leaf spring is used in the case study is of Maruti Omni vehicle ,for Rear Suspension .The conventional steel leaf spring used for experiment is made up of EN45. The composition of material is given below.

| Grade | C% | Mn% | Si % | Cr% | Ni % | Mo % | S,P % (max) |
|---|---|---|---|---|---|---|---|
| En45 | 0.45 - 0.55 | 0.50-0.80 | 0.50 max | 0.80 - 1.20 | - | - | .050* |

TABLE 1-Reference 'Book by Mahindra Ugine Steel Company Limited (MUSCO)'

## VI. Specifications of Existing Leaf Spring

Design Parameters of the existing monoparabolic leaf spring include the leaf span, the weight of the spring, material selected, its camber, density of the material, Tensile strength and Young Modulus.

| Parameter | Value |
|---|---|
| Material selected - steel | 55Si2Mn90 |
| Young's Modulus (E) | $2.1x10^{11}$ (N/mm2) |
| Spring Weight | 3.5Kg |
| Tensile Strength | 1960 (N/mm2) |
| Leaf Span | 1025 (mm) |
| Camber | 90.81 mm |
| Density | .00007850 kg/mm3 |

TABLE 2 - Specification of Existing Leaf Spring

## VII. Simulation of Mono-Parabolic Leaf Spring Using Fem

The monoparabolic leaf spring is first modeled in Pro-E 5.0 and then exported to ANSYS where it is further meshed, constrained and loaded and simulated further. All the analysis for the composite leaf spring is done by using ANSYS 10.0. For composite materials the same parameters are used as that of the conventional leaf spring. For designing of composite leaf spring also the camber is taken 90.81 mm. The two eye ends are rolled and constraints are given. Whenever loads are applied at the eye end section it becomes is free to travel in longitudinal direction. This particular motion will help leaf spring to get flattened when the load is applied.. Produced results are very well compared with the realistic leaf spring and it's Experimental Procedure. The range of loads is applied and results are analyzed. The maximum principle stress is evaluated by software i.e. Von Mises Stress and Maximum Deflection is also observed. It is very much clear from the results produced by the ANSYS for Conventional Steel Leaf Spring, that red colored area indicated that eye end is the possible failure area for leaf spring .Meshing is a process in which geometry is discretized into nodes and elements The structure are meshed and has nodes and elements in it.

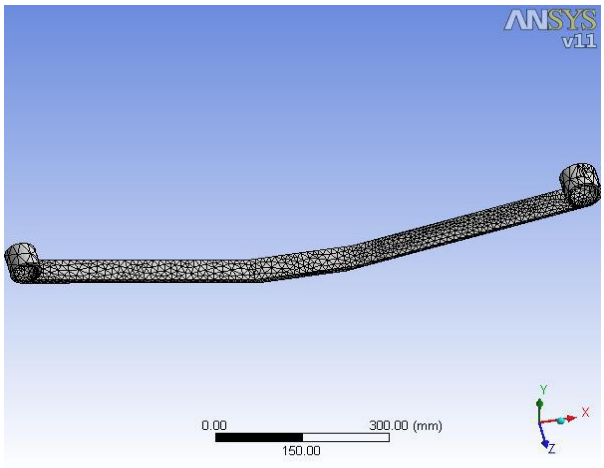



FIG1-MESHED MODEL OF LEAF SPRING

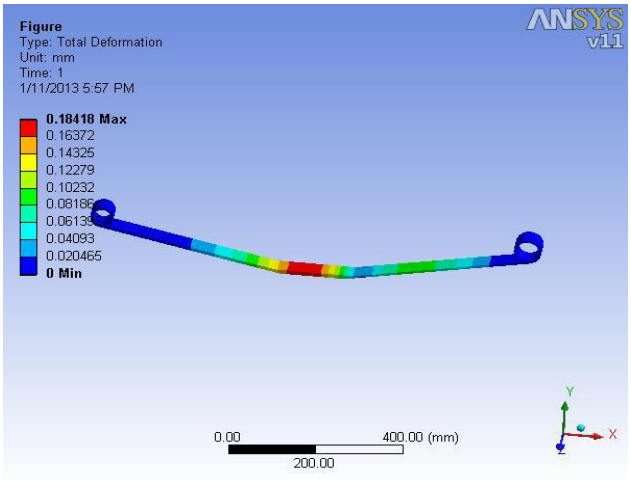



FIG2-TOTAL DEFORMATION AT 1200N FOR EN45

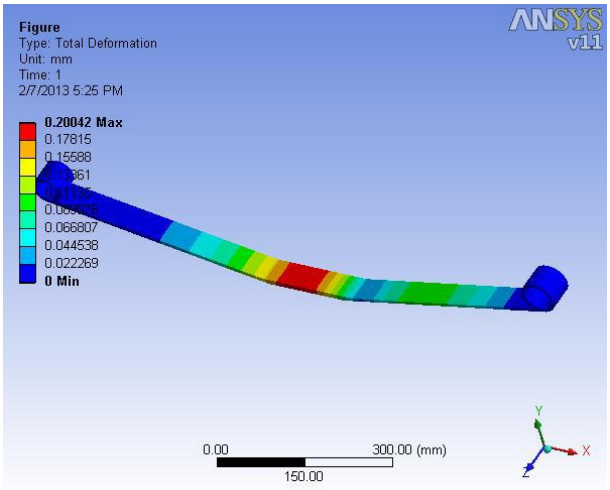



FIG3-TOTAL DEFORMATION AT 1200N FOR HM CARBON

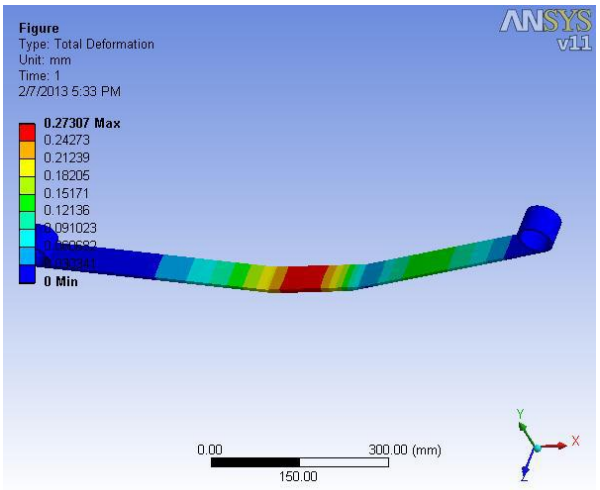
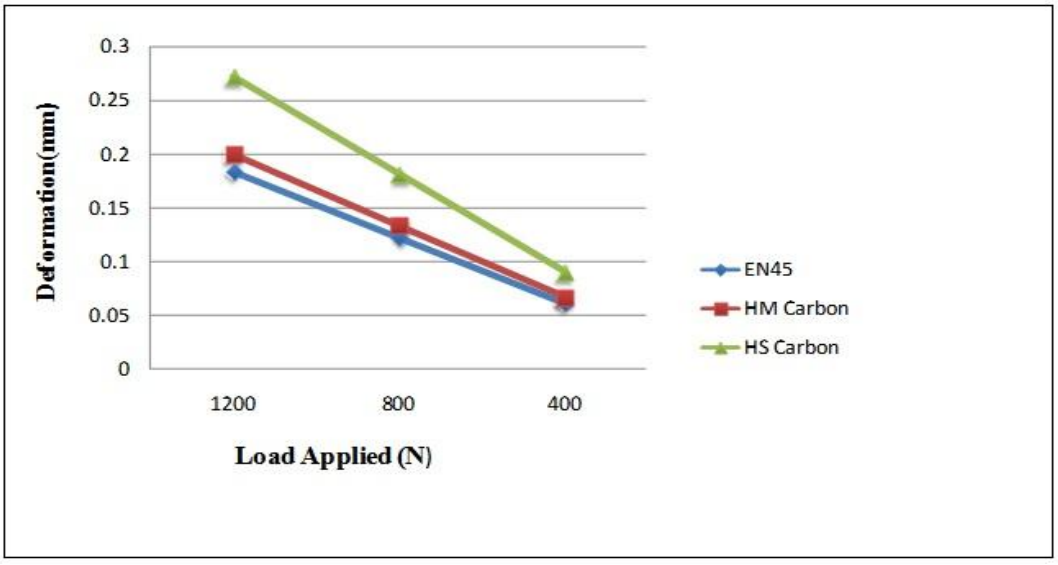



FIG4-TOTAL DEFORMATION AT 1200N FOR HS CARBON

## VIII. Analysis Of Leaf Spring Using Fem

A stress analysis is performed using FEM and a comparative analysis of load and deflection of steel and the composite leaf springs is done. The total defelction in the leaf spring for three loading conditions i.e 1200N, 800N and 400 N is depicted below.



The above graph shows a comparative analysis of deformation of conventional steel used and the virtual models of HS and HM composite leaf springs.

## IX. Conclusion

A comparative study has been made between carbon composite leaf spring and steel leaf spring with respect to weight and strength.The original steel leaf spring would weigh about 3.5 kgs whereas composie leaf spring would weigh 0.7314 kgs. So,we have observed that almost 65-70% of weight reduction could be achieved by using the carbon composites.At various loading conditions the composites under study show deflection as compared to conventional steel.The study has demonstrated that composite leaf springs would offer substantial weight savings.

## REFERENCES

[1] "Optimal Design Of A Composite Leaf Spring Using Genetic Algorithms" By Rajendran,I.,Vijayrangan,S. Int. Jr. Of Computer and Structures 79 2001:Pp.1121-1129
[2] "Design and Analysis of a Composite Leaf Spring" by Rajendran,I.,Vijayrangan,S., Journal of Institute Of Engineers India,82,2002,180-187
[3] "Analysis and Optimization of a Composite Leaf Spring" by Mahmood M.Shokrieh, Dawood Rezaei, Int. Jr. Of Computer and Structures 60 2003:pp317-325
[4] "Analytical and Experimental Studies on Fatigue Life Prediction Of Steel and Composite Multi-leaf Spring for Light Passenger Vehicle Using Life Data Analysis" by Mouleeswaran.S .Kumar, S.Vijayrangam, ISSN 2249-6645 Materials Science. Vol.2, Issue4, July-Aug 2012 pp-1875-1879
[5] Design and Analysis Of Composite Leaf Spring In Light Vehicle" by M.Venkatesan, D.Helmen Devraj Int. Jr. Of Modern Engineering Research (IJMER) Vol.2, issue1, Jan-Feb 2012 pp-213-218
[6] "Modeling and Analysis of Laminated Composite Leaf Spring under the Static Load Condition by using FEA" by M.Raghvedra, Syed Altaf Hussain, V.Pandurangadu, K.Palani Kumar, Int. Jr. Of Modern Engineering Research (IJMER) Vol.2, issue 4, July-Aug.2012 pp-1875-1879
[7] "Mono Composite Leaf Spring for Light Weight Vehicle-Design, End Joint Analysis and Analysis and Testing" by G.S.Shiva Shankar, S.Vijayarangan, ISSN 1392-1320 Materials Science. Vol.12, No.3.2006
[8] "Automobile Leaf Springs from Composite materials" by H.A.AL-Qureshi, Journal of Material Processing Technology, 118, 2001, 58-61
[9] "Mono Composite Leaf Spring for Light Weight Vehicle Design, End Joint Analysis and Testing" by Vijayrangan.S, Gulur Siddharamanna Shiva Shankar, Material Science, 12 (3), 2006, 220-22
[10] "Analytical and Experimental studies on Fatigue life Prediction of steel leaf Soring and composite leaf multi leaf spring for Light passenger vehicles using life data analysis"by Senthil kumar and Vijayarangan, ISSN 1392 13material science Vol. 13 No.2 2007.
[11] "Mono Composite Leaf Spring for Light Weight Vehicle Design, End Joint, Analysis and Testing"by Shiva Shankar and Vijayarangan ISSN 1392 Material Science Vol. 12, No.3, 2006.
[12] "Modelling and Analysis of Composite Leaf Spring under the Static Load Condition by using FEA" by M.M.Patunkar, D.R.Dolas International Journal Of Mechanical & Industrial Engineering, Volume 1 Issue-2011