Design and Analysis of Leaf Spring by Using Hybrid Composite Material

Md Abdul Mustajeeb[1], *S Udaya Bhaskar*[2]
Department of Mechanical engineering
Mallareddy Engineering college(A), Secunderabad, Telangana-500100
Corresponding author: Mustajeeb28@gmail.com

ABSTRACT:

Weight reduction even as growing or maintain the strength of goods is becoming a very significant explore problem in the current planet. Composite resources are one of the families of materials that attract researchers and are solutions to such a problem. In this article, we depict the design and analysis of a complex leaf spring. The goal is to evaluate the stress plus burden loss of the composite leaf spring by the load of the steel leaf spring. A structural limitation is rigidity. The automotive industry is showing great interest in replacing steel leaf springs with composite leaf springs, since composite materials have a high strength-to-weight ratio and good corrosion resistance. The selected material was fiberglass reinforced polymer (E-glass / epoxy), carbon Fiber are old beside ordinary steel. The design parameter were certain and analyzed in order to minimize the weight of the composite leaf spring as in comparison with a steel leaf spring. The leaf spring was modelled in the CATIA V5 R20 plus The analysis was performed by ANSYS 16.0 software is Static, Modal and Harmonic analysis.

Key words: - composite leaf spring, steel leaf spring, ANSYS 16.0, CATIA V5 R20.

1. INTRODUCTION

Leaf springs are the optimized drift in serious business vehicles for semi-active plus inactive motor vehicle delay system. It has always be attractive to employ compound spring more than steel springs, as they are extra unwilling to fatigue than steel springs. In addition, composite springs are more inexpensive plus lighter than steel springs. The foreword of hard particle into the polymer objects of complex spring lead to an development in the automatic behavior of the polymer medium of composite springs. force plus robustness increase owed to microparticle fibre. Despite the fact that composites have a lot of compensation above steel, it cannot be totally eliminated, since it provides strapping plus unbending hold up. mainly serious for profit vehicle contain rear-wheel force. A back hinge with a slave drive usually has two longitudinal manage levers plus a Panhard bar to withstand all deviations, as well as brake plus side military, in that order.

scheming makes it possible to eradicate trouble prior to starting making. In adding, it is easy to decide the compassion of exact melding parameter to the excellence plus manufacture of the last fraction. The leaf spring replica is shaped by modeling in CATIA plus import into the scrutiny software, plus the load, border situation are transferred to the import replica, plus the grades be evaluate by the postprocessor. relative leaf spring grades for various layouts of steel leaf spring and composite leaf spring are obtain to forecast the benefits of a composite leaf spring for a motor vehicle.

2. LITERATURE REVIEW

2.1 INTRODUCTION

Composite materials for leaf springs, structure briefly described. Currently, one main strategy is used in specifications and calibration strategies for weight gain.

Shivashankar, Vijayarangan, et.al 2007 [1] A genetic algorithm (GA) approach was used to process a mixed leaf spring with a cross section, and it was found that 93% weight loss was cultivated in spring with this framework

Simran Jeet Singh, Meeenu Gupta [2] The recent particle swarm optimization (PSO) and annealing simulation (SI) approaches are used to optimize the planning of mixed leaf springs. This helps to choose the best combination of planning factors, such as center width and composite spring thickness. Technique for optimizing particle swarm using a composite spring Reduces deflection, stress and weight by about 85% and 78.8% of the weight of simulated annealing compared to steel sheet spring

C. Ajitab Pateria, Makassar Khan [3] examined the powerful features of spring placement using ANSYS. Fluid strong associations of working deformations between the valve circumference and overlying fluids were used to visualize the movement of the valve plate for various materials. Various materials were used subject to comparable marginal conditions to find the best reasonable material. The result of the FEM study shows that La2Zr2O7 is the best material. The most serious shear stress considered is 0.20395 MPa, which is more noticeable for aluminum compounds. Aluminum alloy material should be preferred for weight to cost ratio.

E. Mahdi et al., [4] Steel and composite sheet are considered a spring test. They think of a traditional leaf spring and composite leaf spring (GFRP). They used ANSYS programming to consider a typical steel alloy leaf spring for comparative conditions. They fabricated a glass / epoxy composite leaf spring using a manual layout method. Comprehensive testing machines were used to test the effects of conventional steel and composite leaf springs.

M. Sureshkumar and R. M. [5]. The presence of carbon fiber also reduces the cost of leaf springs and fiberglass. The combination of two types of fibers increases tensile strength and toughness and reduces the weight of the system.

Yu. W.J. and H.C. Kim, n [6]. It is noted that the adhesives have excellent quality in compression and laying in shear, although their appearance is less than that of the strip. Matthews et al. Have suggested that the stress focus at the end of the coverage area can be reduced by changing the geometry.

I. Rajendran and S. [7] demonstrated a phased study of auxiliary adhesive compounds that were subjected to bending and shear stresses.

Abdul Rahim et al. [8] gained direct flexibility when using two-dimensional models of reinforced joints. Anxiety in straight-line cement in an edge-reinforced joint can be assessed using the simple flexibility hypothesis at low removal. He demonstrated that the focal localization of the joint is in a state of uniform pressure.

E. Sanctor and M. Gratton [9] tried to introduce two-rod components and a cement layer with balancing hubs through a linear horizontal component to students to reduce computational effort. In this case, the number of degrees is definitely reduced.

M. Venkatesan and D. Hellman Devaraj [10] made a good assessment of the various methods of breaking adhesive reinforced compounds. He used breakthrough mechanics to identify features found at the junction of biomaterial interfaces, and proposed depressive scales. Representing a simple and elastic-plastic reaction of pupils to a joint, they underwent 19 concentrated single-cavity joints, joints, cuts, and any mixture of small styling. They presented the problem of six non-linear general differential conditions of the first order, using a numerically finite difference method to talk about the effect of statically limited fluctuations in cement flow on a numerically thin adhesive layer.

US. Ramakant and Quesaujania [11], two-dimensional, planar deformation conditions in one circular joint, and investigated using the Non-Direct Component Limited geometric model. Huge distortions that occur during joint styling have demonstrated non-linearity. Although their model is a two-dimensional definition, their results are in full agreement with the available harmonic schemes.

Mr. V. Lakshmi Naryana [12] The core technique was developed taking into account the minutes on the cover tape and displaying individual soft forces on the upper and lower pupils in the cover section and demonstrating a two-dimensional universal oriented response to describe a single-layer adhesive reinforced joint.

Shishai Amare Jibremeskel [13] built a numerical calibration using finite-part technology to plan reinforced joints. They are more focused on

Mana Patnaik and Narendra Yadav [14] originally planned and presented a wavy circular joint. According to them, this new structure not only maintains a strategic distance from pile instability to single-cavity joints, but also allows you to worry about compression in the direction of the end cap segment.

G. Siddaramanna and Sivashankar [15] similarly investigated single-sheet adhesive regulated compounds using the study of the final parts and confirmed their results, temporarily or completely disagreeing with 20 results. They used a geometrically nonlinear two-dimensional finite component technique to study the effects of aircraft deformation and aircraft pressure conditions, bending factors, and cement stresses. The results show that there are no ground differences between the proportions of limited parts made under air pressure and the proportions made in a normal race.

H. A. Al-Qureshi [16] also defended the problem of nonlinearity. They performed two- and three-dimensional studies of the unisexual joint. In two-dimensional testing, they used parts of the Bernoulli shaft with distortion of the hub to display the pupil, while the adhesive layer spoke through the components of plane pressure or plane tension. Part of the Bernoulli shaft is basically a one-dimensional part of two-dimensional space. A comparable methodology was considered, in which shell components were used to communicate with followers, and block components were used to transfer fully three-dimensional details, for example, a cement layer. They promise to see three-dimensional effects during their testing.

A. A. J. M. Pace and J. M. M. De Kock, [17] The flexible arrangement of the wavy joints of the knees is regulated in the joints of the wavy circle and eliminates damage.

J. P. Hou et al., [18] developed detailed responses for adhesive reinforced composite compounds to evaluate problems with the cement layer. For this study, the old-style overlay hypothesis and composite model of the cement interface were used.

Robert D. presents a two-dimensional finite element study of composite reinforced single-component compounds. The eight-hub isoperimetric plane in his model makes good use of the six-hub interface components with strong components. The end parts of the interface are installed on the interfaces between the adhesive between the cement composition and the interface between the various layers to obtain a pressure field at the interface.

3. METHODOLOGY

Weight Calculation

1. For current steel leaf spring

From the mass, density and volumes relation the weight of the leaf spring can be calculated as

Density = $\frac{mass}{volume}$

$\rho = \frac{M}{V}$

$M = \rho * V$

$W = M*g$, Where $M = \rho * V$

Therefore, $W = \rho * V *g$

Density of structural steel = 7.85 gm/cm^3 and

Acceleration due to gravity (g) = 10 m/s^2

Now weight of the leaf spring (W) = ρ *Vs*g

Vs = L*t*w

=1000mm*28mm*45mm, where

Vs = volume of the leaf spring

L= length

t = thickness and

w = width

Vs = 1260 cm^3

W = 7.85 gm/cm^3 * 1260 cm^3 * 10 m/s^2

W = 98.91 N

2. For Carbon Fiber Leaf Spring

Weight of the leaf spring calculated as

Wc = ρc*Vc*g

Vc = L*t*w

= 1000mm*28mm*45mm

= 1260 cm^3

Wc = 1.5 gm/cm^3 * 1260 cm^3 * 10m/s^2

Wc = 18.90 N

Now calculation the weight saved of the leaf spring

Weight saving = 98.91 – 18.90 = 80.01 N

% weight saved = $(\frac{80.01}{98.91})*100 = 80.89\%$

Therefore, the carbon fiber composite mono leaf spring is very light weight material than conventional steel.

3. For E-glass Leaf Spring

Weight of the laf spring calculated as

Wg = ρg*Vg*g

Vg = L*t*w

= 1000mm*28mm*45mm

= 1260 cm^3

Wg = 1.6 gm/cm^3 * 1260 cm^3 * 10m/s^2

Wg = 20.16 N

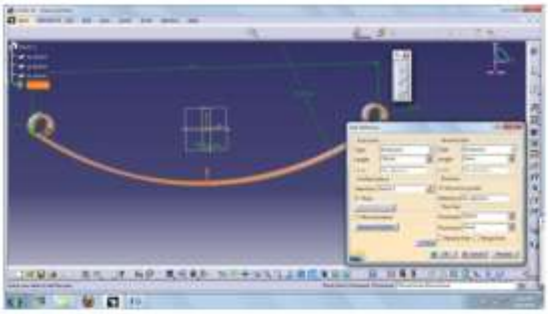
Now calculation the weight saved of the leaf spring

Weight saving = 98.91 – 20.16 = 78.75 N

% weight saved = (78.75 / 98.91) *100 = 79.61%

Therefore, the E-glass composite mono leaf spring is very light weight material than conventional steel.

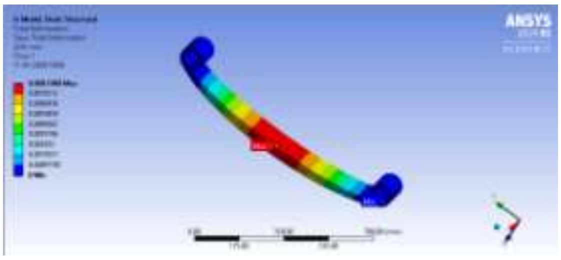
4. MODELLING



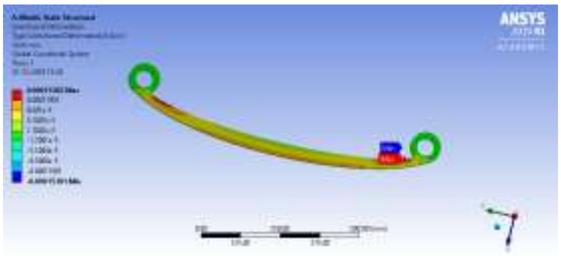
5. RESEARCH ANALYSIS

In present work static structural analysis of leaf spring is done. To perform static structural analysis boundary and loading conditions need to be defined. Whole leaf spring assembly is import to ANSYS 16.0 workbench in. igs format as a single part for simplification of analysis. Static analysis is done with maximum displacement constrained to 5mm. Arrangement of Leaves of Different Materials in Leaf Spring in Different Cases.

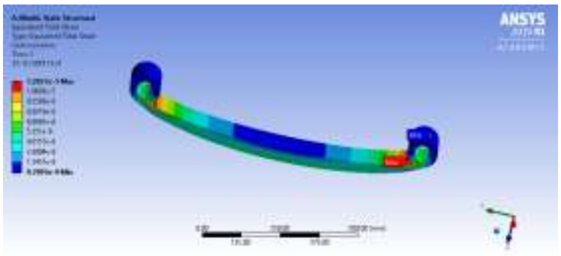
5.1 RESULTS FOR STRUCTURAL STEEL



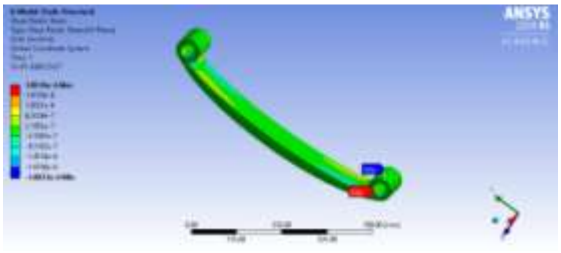
Total Deformation steel



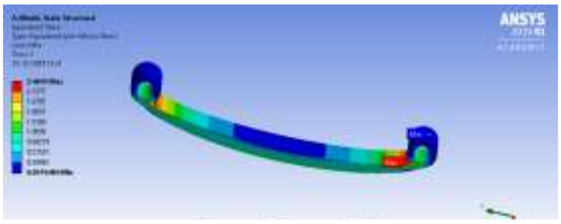
Directional deformations for steel



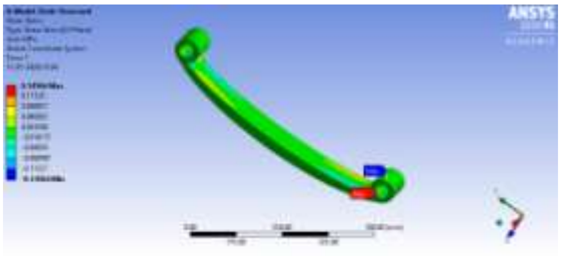
Equivalent Elastic Strain for steel



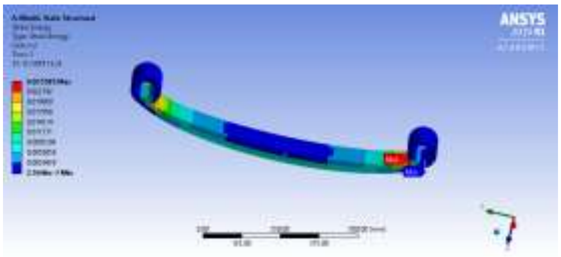
Shear Elastic Strain for steel



Equivalent stress for steel

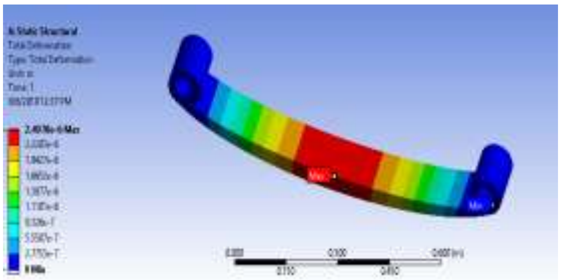


Shear stress for steel

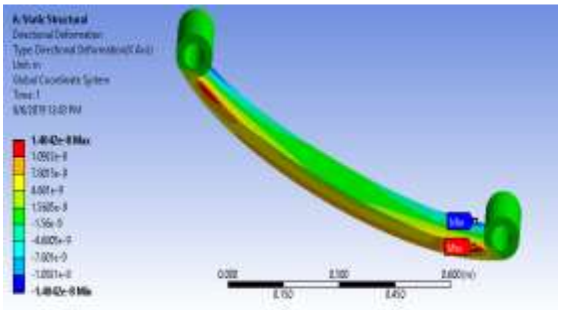


Strain Energy

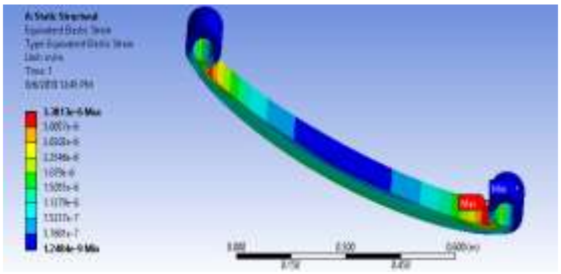
5.2 RESULTS FOR CARBON FIBER



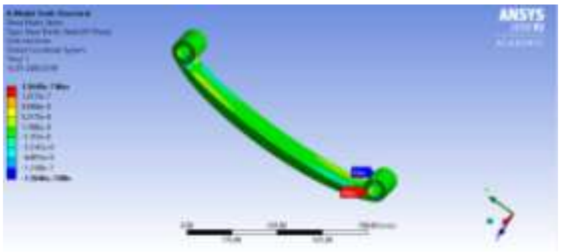
Total Deformation of Carbon Fiber



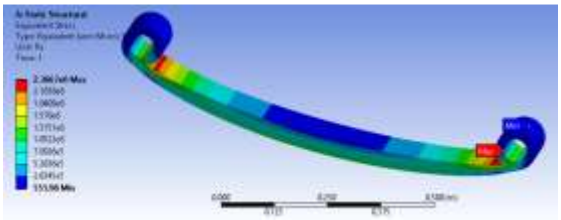
Fiber



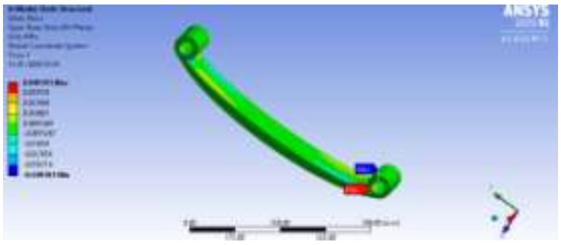
Equivalent Elastic Strain of Carbon Fiber



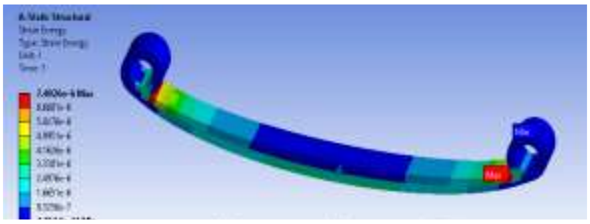
Shear Elastic Strain of Carbon Fiber



Equivalent Stress of Carbon Fiber

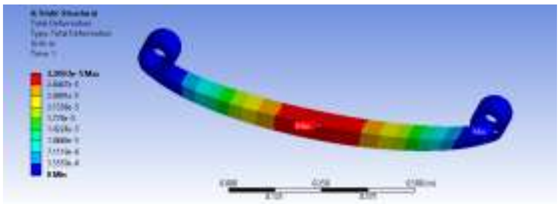


Shear Stress of Carbon Fiber

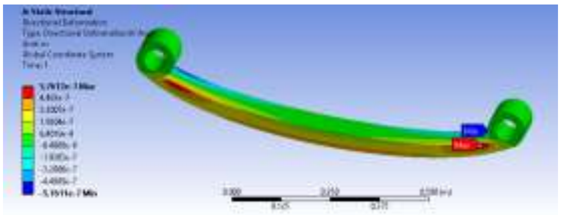


Strain Energy of Carbon Fiber

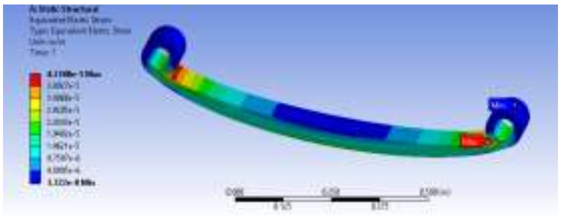
5.3 Results for E-Glass Epoxy



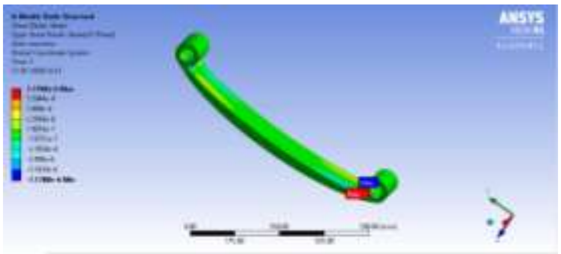
Total Deformation of E-Glass



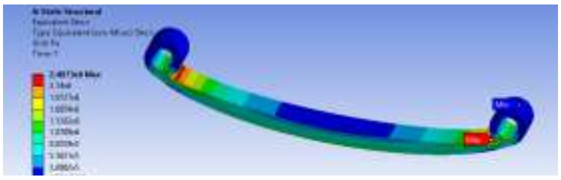
Directional Deformation of E-Glass



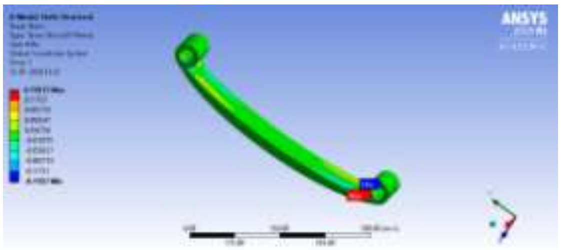
Equivalent Elastic Strain of E-Glass



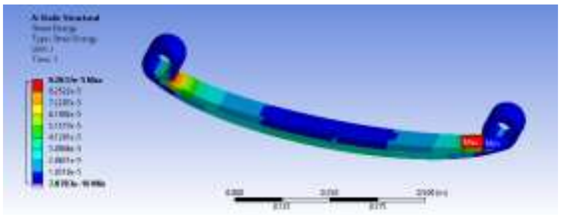
Shear Elastic Strain of E-Glass



Equivalent Stress of E-Glass

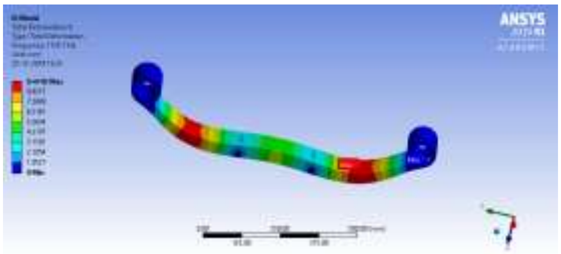


Shear Stress of E-Glass

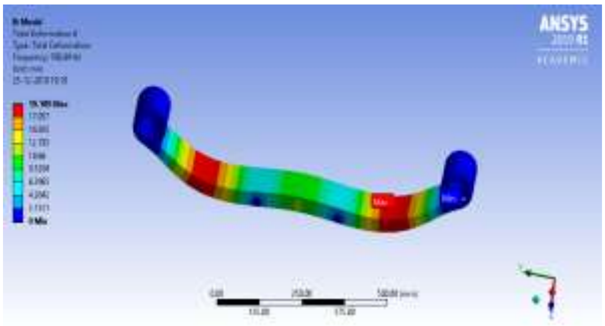


Strain Energy of E-Glass

5.4 MODAL ANALYSIS:

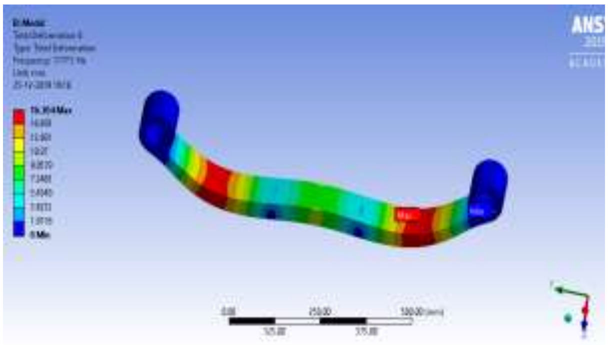


Natural Frequency of Steel



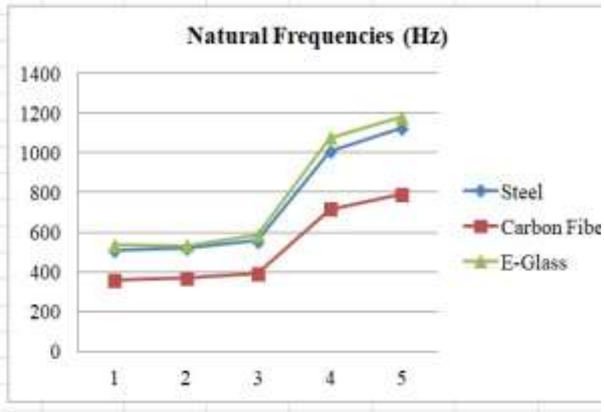
Natural Frequency of Carbon Fiber

`

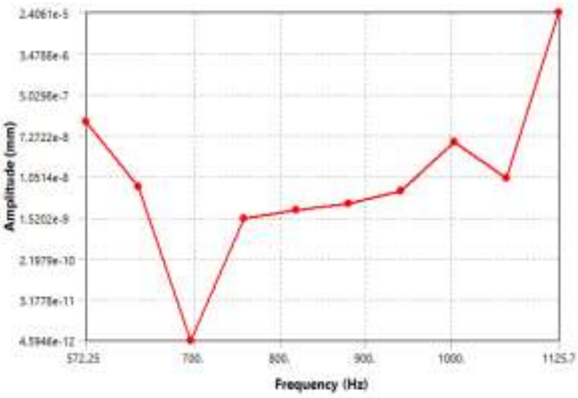


Natural Frequency of E-glass

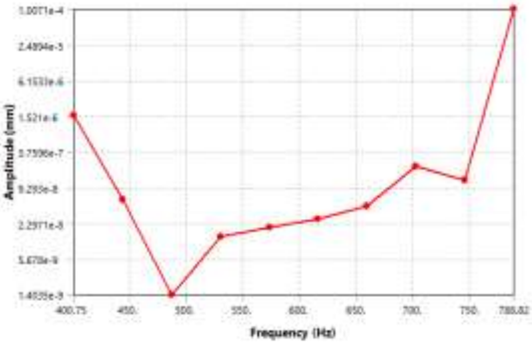
5.4.1 Natural Frequencies



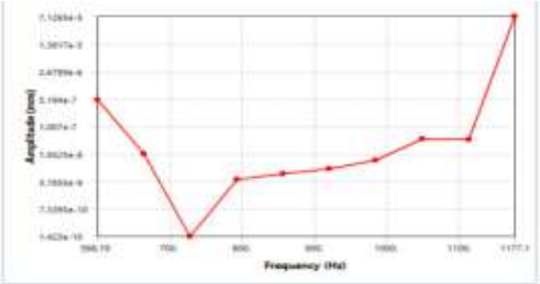
5.5 HARMONIC RESPONSE



Harmonic response for steel



Harmonic response for carbon fiber



Harmonic response for E-glass fiber

6 RESULTS

Total Deformations

Material	Minimum	Maximum
Steel	0	8.7989e-008 mm
Carbon Fiber	0	2.4978e-003 mm
E-Glass	0	3.2003e-002 mm

Table 6.1 Total Deformations

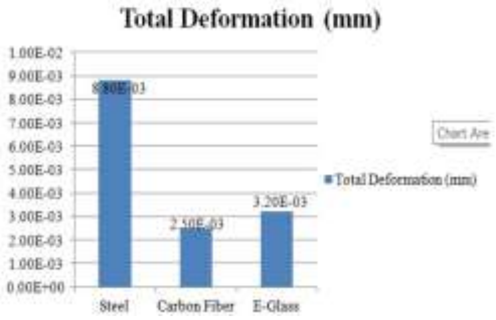


Fig 6.1 Total Deformations

Directional Deformations

Material	Minimum	Maximum
Steel	-1.5301e-004 mm	1.5302e-004 mm
Carbon Fiber	-1.4042e-005 mm	1.4042e-005 mm
E-glass	-5.7611e-004 mm	5.7612e-004 mm

Table 6.2 Directional Deformations

Equivalent Elastic Strains

Material	Minimum	Maximum
Steel	9.7995e-009 mm/mm	1.2027e-005 mm/mm
Carbon Fiber	1.2484e-009 mm/mm	3.3813e-006 mm/mm
E-glass	3.722e-008 mm/mm	4.3788e-005 m/m

Table 6.3 Equivalent Elastic Strains

Shear Elastic Strains

Material	Minimum	Maximum
Steel	-1.8933e-006 mm/mm	1.893e-006 mm/mm
Carbon Fiber	-1.5646e-007 mm/mm	1.5646e-007 mm/mm
E-glass	-7.1788e-006mm/mm	7.1798e-006mm/mm

Table 6.4 Shear Elastic Strains

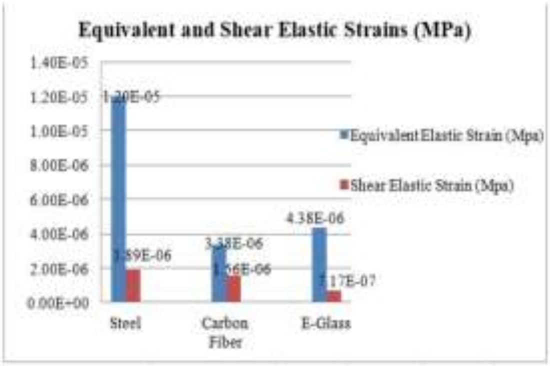


Fig 6.2 Equivalent and Shear Elastic Strains

Equivalent Stresses

Material	Minimum	Maximum
Steel	1.6484e-003 MPa	2.4045 MPa
Carbon Fiber	5.5198e-004 MPa	2.3667 MPa
E-glass	1.7369e-003 MPa	2.4073 MPa

Table 6.5 Equivalent Stresses

Shear Stresses

Material	Minimum	Maximum
Steel	-0.14564 MPa	0.14566 MPa
Carbon Fiber	-4.9781e-002 MPa	4.9791e-002 MPa
E-glass	-0.1507 MPa	0.15072 MPa

Table 6.6 Shear Stresses

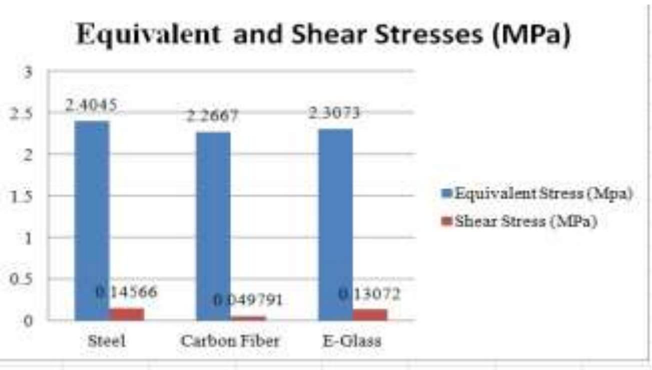


Fig 6.3 Equivalent and Shear Stresses

Materials	Minimum	Maximum
Steel	2.1646e-007 mJ	2.5585e-002 mJ
Carbon Fiber	4.7634e-008 mJ	7.4926e-003 mJ
E-glass	7.8782e-007 mJ	9.2837e-002 mJ

Table 6.7 Strain Energies

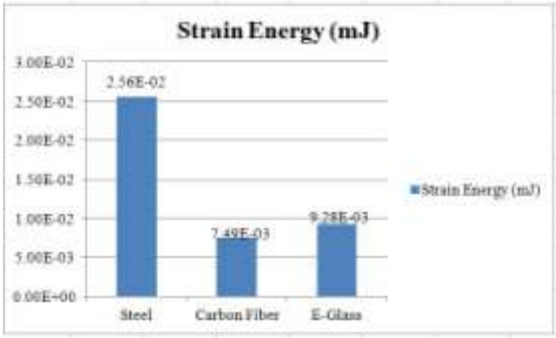


Fig 6.4 Strain Energies

7 CONCLUSION

CAE tool CATIA is used for 3d modeling of leaf spring. This method is more cost effective less time consuming then other methods of modeling. Leaf spring assembly file in IGES file format is exported to ANSYS 16.0 for analysis. ANSYS 16.0 is used for meshing and analysis of leaf spring. This method of analysis is more cost effective, efficient and less time consuming than other methods of solution.

Structural analysis of leaf spring for different material combination under similar loading condition has been done for all design cases.

Results for selected parameters are obtained for all design cases of leaf spring.

Total deformation, equivalent elastic strain, equivalent (Von-Mises) stress, strain energy and mass results have been analyzed for different material combination in different design cases of leaf spring.

REFERENCES

1) Shiva Shankar and Vijayarangan "Mono compound leaf spring for glow mass vehicle design, end link, study and examining" issn 1392 fabric science.
2) Simran jeet singh and meenu Gupt "Springs - A Essential investigation of auto suspension", The Auto motor Journal,
3) C. Ajitabha Pateriya "Kamis, Khukuri producers of Nepal". Himalayan-imports.com.
4) E. Mahdi, et al., “Light composite elliptic spring for vehicle suspension,” comps. Struc., 75, 24-28 (2006).
5) M. Sureshkumar and R. Dharmalingam “Design, fabrication and analysis of a hybrid fiber composite material for automotive suspension application”.
6) Yu W. J. and H.C. Kim, “Double tapered FRP beam for automotive-suspension leaf spring,” comps. Struct., 9, 279-300 (1988)
7) I. Rajendran and S. Vijayarangan. “Optimal design of composite leaf spring using genetic algorithms,” Computers and structures, 79, 1121-1129 (2001).
8) Abdul rahim et al., “Developing a composite-based elliptic spring for automotive applications.” MATERIAL AND DESIGN, 31, 475-484 (2010).
9) E. Sancaktar and M. Gratton, “Design, analysis, and optimization of composite leaf springs for light vehicle applications,” compos. Struct., 44, 195-204.
10) M. Venkateshan, D.helmen Devraj, “design and analysis of leaf spring in

light vehicles”, IJMER 2249-6645 Vol.2, (2012).

11) U.S. Ramakant and K.sowjanya, “Design and analysis of automotive multi leaf spring using composite material”, IJMPERD 2249-6890 Vol.3, (2013).
12) Mr V. Lakshmi Naryana, Design and analysis of mono composite leaf spring for suspension in automotives” IJERT 2278-0181, Vol. 1(2012).
13) Shishay Amare gebremeskel, “Design, simulation, and Prototyping of single composite leaf spring for Light weight vehicle “, IJMER 2249-6645,Vol.2 (2012).
14) Manas Patnaik, Narendra Yadav, “Study of a parabolic leaf spring by finite element method and Design Experiments”, (2012).
15) G. Siddaramanna and Shivashankar, “Mono composite Leaf spring for a lightweight Vehicle- design, end joint analysis and testing,” mater.sci, Vol.12. No.3 ISSN 1392-1320,(2006).