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# Design and Analysis of Composite Leaf Spring using composite material for light vehicle

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**Abstract** —*A leaf spring is a simple form of spring, normally used for the suspension in wheeled cars. Leaf springs are long and narrow plates attached to the body of a trailer that rest above or under the trailer's axle. For safe and cozy using, to prevent the street shocks from being transmitted to the car components and to guard the occupants from road shocks it's miles important to determine the maximum safe strain and deflection. The objective is to find the stresses and deformation in the leaf spring via making use of static load on it. one-of-a-kind materials with special mechanical properties are taken into consideration for the structural static evaluation. consequently within the gift paintings, leaf spring is designed by means of considering static load on automobile. The version of leaf spring is created in stable works with 3 different materials steel,glass epoxy,carbon epoxy.the load acing on each spring is considered as 5375N.the deformation, stress and strain is analyzed by using ansys.The comparison between the three materials are studied.*

***Keywords****-leaf spring,composite material,carbon epoxy,Mahindra commander,solidworks,ANSYS.*

## I. INTRODUCTION

Leaf springs square measure in the main employed in suspension systems to soak up shock masses in vehicles like light-weight cars, serious duty trucks and in rail systems. It carries lateral masses, brake force, driving forceadditionally to shock interesting. The advantage of spring over coiled spring is that the ends of the spring could also beguided on a precise path because it deflects to act as a support additionally to energy interesting device.According to the studies created a cloth with most strength and minimum modulus of physical property within the longitudinal direction is that the most fitted material for a spring.

### 1.8objective

The objectives of the project are:

a) To design and analyse leaf spring with composite material.
b) To model a composite leaf spring with specific dimensions using solidworks.
c) To provide optional material for leaf spring as the usage of composite materials has resulted in considerable amount of weight saving in the range
d) To design and analyse a composite leaf spring with different material for an automobile like conventional steel and new carbon fibre.
e) To compare the results of conventional steel spring and new carbon fibre shafts.

### 1.9Methodology

The solution for the problem is performed in three stages - Theoretical Analysis, Creating a Solid Model, Finite Element Analysis.

#### A. Theoretical design

Theoretical design is performed by using the basic concepts of Strength of Materials.

#### B. Creating a Solid Model

A Three Dimensional solid model of leaf spring is created on the computer using CATIA This 3D Model is exported to Ansys for performing Finite Element Analysis.

#### C. Finite Element Analysis

There are three main steps, namely: pre-processing, solution and post processing.
Modelling –CATIA
Analysis – ANSYS workbench 16.0

 

## II. LITERATURE REVIEW

**[1]. P saikrishna, 2 s vigneshwaran, 3 ramarajusrinivasara** A spring may be a easy type of spring, commonlyused for the suspension in wheeled vehicles. Leafsprings square measure long and slender plates hooked up to theframe of a trailer that rest on top of or below the trailer'saxle. For safe and cozy riding, to stop theroad shocks from being transmitted to the vehiclecomponents and to safeguard the occupants fromroad shocks it's necessary to work out themaximum safe stress and deflection. the target isto realize the stresses and deformation within the leaf springby applying static load on that. completely different materials withdifferent mechanical properties square measure thought-about for thestructural static analysis. thus within the presentwork, spring is meant by considering staticload on vehicle. The model of spring is made insolid works with 3 completely different thickness 4mm, 5mmand 6mm and analysis is finished victimisation ansys fourteen.5workbench with 3 completely different materials such asCarbon epoxy, steel E-glass epoxy. therefore thestructural analysis is dispensed at 6685N force andstress, strain, most shear stress and totaldeformation values realized.

[**2] Dev Dutt Dwivedi1, V. K. Jain** Design and analysis of composite leaf springhas been wiped out this paper. ANSYS14.5 has been wont to conduct the analysis.Static structural tool has been used of ANSYS.A three layer composite spring with full length leave. E-Glass/epoxy composite material has been used. typical steel spring results are compared with the gift results obtained for composite leaf spring. E-glass/epoxymaterial is healthier instrength andlighter in weight as distinction with conventional steel spring. a good amount of study has been conducted during this paper toin vestigatethestyle and analysis of spring and springfatigue life.

**[3]Mr. Tharigonda Niranjan Babu *,Mr P. Bhaskar, Mr. S. Moulali** In automobile sector tends to increasing competition and innovation in style and tends to switch the existing product by new and advanced materials. Leaf springs area unit special quite springs utilized in automobile suspension systems. the most operate of spring isn't solely to support vertical load however conjointly to isolate road induced vibrations. it's subjected to several load cycles resulting in fatigue failure. The introduction of composite materials has created it attainable to scale back the burden of the spring with none reduction in load carrying capacity and stiffness. thus the target of this paper is to gift a general study on the performance comparison of composite (E-Glass/Epoxy and Jute E-Glass) spring and traditional spring. spring is sculptural in CATIA V5R20 package and it's foreign in ANSYS twelve.0. the traditional composite leaf springs were analyzed under similar conditions victimisation ANSYS package and therefore the results area unit given. The automobile chassis is mounted on the axles, not direct however with some style of springs.

## III. LEAF SPRING SPECIFICATIONS

For study and analysis we are considering the specifications of leaf spring of Mahindra commander 650 DI.following table gives the all dimensions and values regarding the automobile.the material used for spring is steel is considered.the property table for steel is given below.

### 3.1 Specification of mahindra commander 650 di leaf spring of jeep

**Table no 3.1: Material properties of structural steel EN45**

| SR No | Parameter name | Value |
|---|---|---|
| 1 | Material | Steel EN45A (0.61%C,1.8%Si, 0.79%Mn,0.02%S, 0.024P) |
| 2 | Leaf span (2L) | 1120 mm |
| 3 | No of Full length leaves | 2 |
| 4 | No of graduates leaves | 8 |
| 5 | No of leaves | 10 |
| 6 | Width (b) | 50 mm |
| 7 | Thickness (t) | 6 mm |
| 8 | Young Modulus of leaf spring (E) | 210000 MPa |
| 9 | Ineffective length | 100 mm |

 

**Table 3.2 : Material properties of leaf spring**

| **Steel** | **EN45 A** |
|---|---|
| Young Modulus [E] | $2.1^{5}$ N / $mm^2$ |
| Poisson Ratio | 0.266 |
| Ultimate tensile strength | 1272 MPa |
| Yield Tensile strength | 1158 MPa |

### 3.4 Dynamic Specification of Mahindra commander 650 di Jeep:

| **SR. No** | **Parameter** | **Value** |
|---|---|---|
| 1 | Gross vehicle weight | 2150 Kg |
| 2 | Wheelbase(b) | 2680 mm |
| 3 | Engine | MDI3000 |
| 4 | Type | Four stroke over square, Four cylinder inline |
| 5 | Weight of engine | 275 kg |
| 7 | Suspension | Front and Rear :Semi Elliptical leaf spring |
| 8 | Wheel, Rim, tyre | 6 inches |
| 9 | Track width | 3 m |
| 10 | Turning circle radius | 60 m |

## IV MATERIAL STUDY

### 4.1 Conventional material –steel

SM45 Plastic Mold Tool Steel tool steel that is characterized by good toughness at moderate strength levels Quality guarantee and reliable service make us a better choice for you for P20 special tool.Applications: For the production of all kinds of plastic mold, high mirror mold, mold base, etc.
Chemical composition (mass fraction)(wt.%)

| C | Si | Mn | P | S |
|---|---|---|---|---|
| 0.42-0.48 | 0.17-0.37 | 0.50-0.80 | 0.030 | 0.030 |

**Table 4.1: Material properties of steel (sm45)**

| SR. No. | Mechanical properties | Symbol | Units | Value |
|---|---|---|---|---|
| 1 | Young's modulus | E | GPa | 207.0 |
| 2 | Shear modulus | G | GPa | 80.0 |
| 3 | Poisson's ratio | υ | ---- | 0.3 |
| 4 | Density | ρ | Kg/m3 | 7600 |
| 5 | Yield strength | Sy | MPa | 370 |
| 6 | Shear strength | Sx | MPa | 275 |

 

**4.2 glass epoxy**

**Table 4.2: material properties of glass epoxy composite**

| Properties | ***Glass epoxy*** |
|---|---|
| Density (kg/m3) | 2000 |
| Yong's Modulus E (GPa) | 50 |
| Longitudinal tensile fracture strength (MPa) | 800 |
| Poisson's Ratio | 0.3 |
| Transverse tensile strength (MPa) | 40 |
| Shear strength (MPa) | 30 |
| Shear Modulus(GPa) | 5.6 |

4.3

**4.3 Composite material carbon-epoxy**

**Table 4.3: material properties of carbon/epoxy composite**

| N | Property | Symbol | Units | Carbon/Epoxy |
|---|---|---|---|---|
| 1 | Youngs modulus | E | GPa | 190 |
| 2 | Transverse Modulus | E22 | GPa | 7.7 |
| 3 | Shear Modulus | G12 | GPa | 4.2 |
| 4 | Poisson's Ratio | υ | ----- | 0.36 |
| 5 | Density | ρ | Kg/m3 | 1600 |
| 6 | Longitudinal Tensile strength | St1 | Mpa | 870 |
| 7 | Transverse Tensile strength | St2 | Mpa | 540 |
| 8 | Shear strength | Ss | Mpa | 30 |

**4.4 Calculations**

Here Weight and initial measurements of Mahindra
"Model - commander 650 di" light vehicle are taken.
Gross vehicle weight = 2150 kg
Acceleration due to gravity (g) = 10 m/s²
There for; Total Weight (W) = 2150*10 = 21500N
Since the vehicle is 4-wheeler, a single leaf spring corresponding to one of the wheels takes up one fourth of the total weight.
F = 21500/4 = 5375 N

## V LEAF SPRING SPECIFICATIONS

**5.1 Computer aided design**

CAD had its origins in 3 separate sources, that additionally serve to spotlight the fundamental operations that CAD systems give..

**5.2 Solidworks**

SolidWorks may be a 3D solid modeling package that permits users to develop full solid models during a simulated atmosphere for each style and analysis

**5.3 Finite element analysis**

There ar 3 main steps, namely: pre-processing, answer and post process. In pre-processing (model definition) includes: outline the geometric domain of the matter, the component type(s) to be used, the fabric properties of the weather, the geometric properties of the weather (length, area, and also the like), the component property (mesh the model), the physical constraints (boundary conditions) and also the loadings

**5.4 Ansys**

ANSYS may be a general purpose computer code, accustomed simulate interactions of all disciplines of physics, structural, vibration, fluid dynamics, heat transfer and magnetic attraction for engineers..

 

**5.4.1 Structural analysis**

Structural analysis is that the determination of the consequences of masses on physical structures and their elements.

**5.5 Statistical analysis of leaf spring**

5.5.1 After creating solid model of steel leaf spring in Solidworks. Save that model in STEP format.

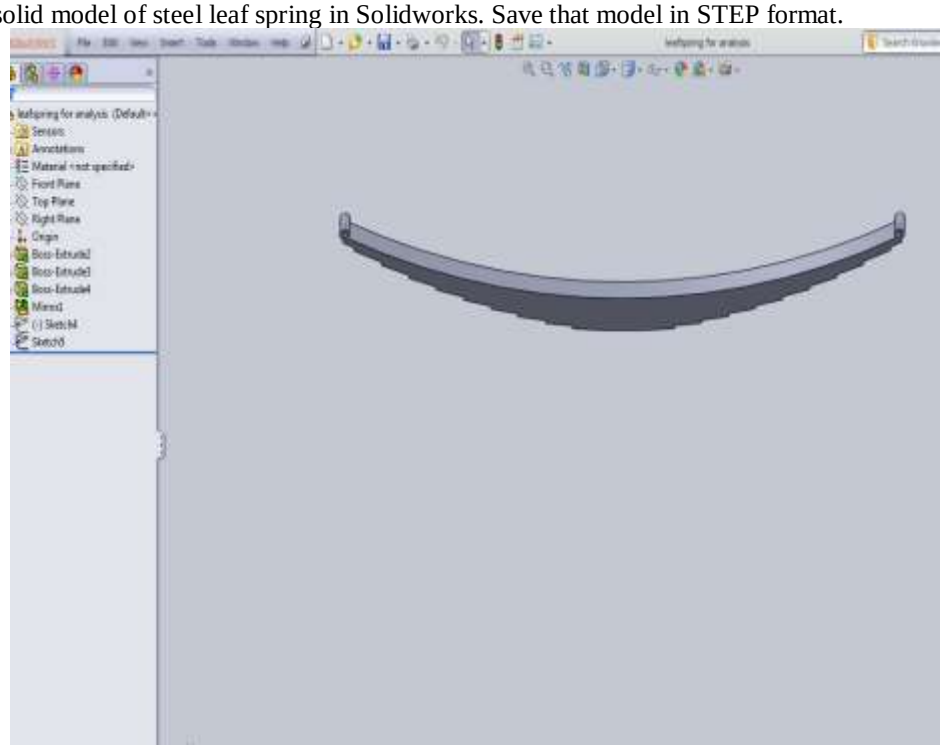

**Fig no: 5.1 design of leaf spring for specific dimensions in leaf spring**

**5.5.2 Import above 3D model in ANSYS Workbench static structural module for static analysis.**

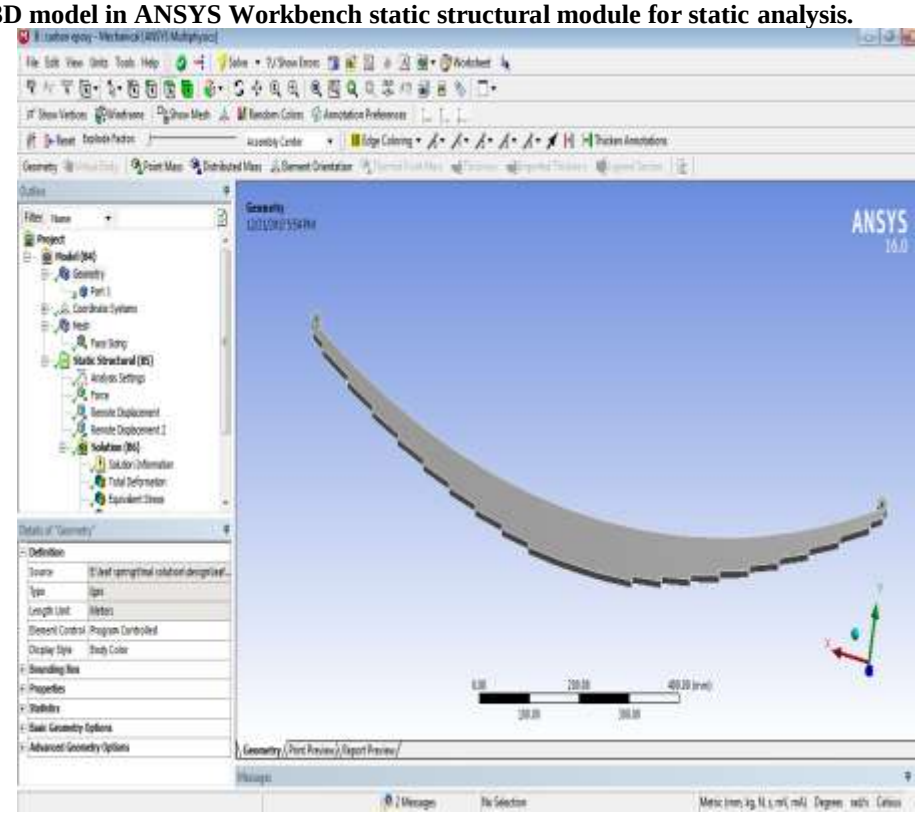


**Fig no 5.2:importing 3D model in ansys**

**5.5.3 Create leaf spring material steel.**

Provide material properties as per table 4.1 in the ANSYS Workbench

 

**5.5.4 assign material**

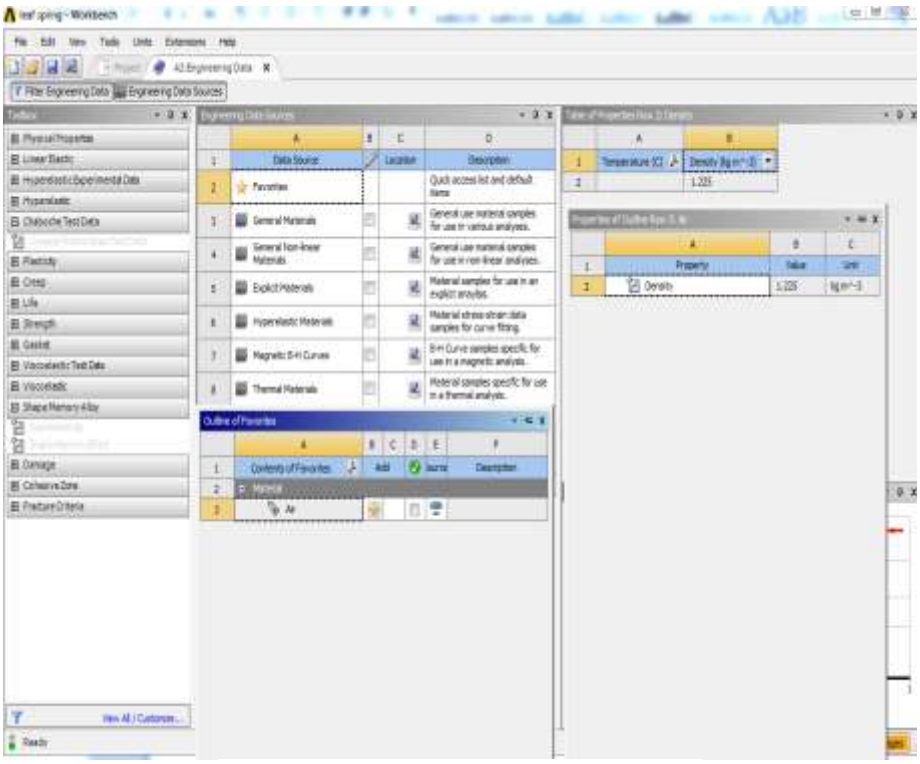

**Fig no 5.4 :assignment of material in ansys**

**5.5.5 Create meshing of leaf spring.**

Meshing is that the method during which your pure mathematics is spatially discredited into elementsand nodes. This mesh along side material properties is employed to mathematicallyrepresent the stiffness and mass distribution of the structure.

• Type of meshing: 3D
• Type of elements: Automatic

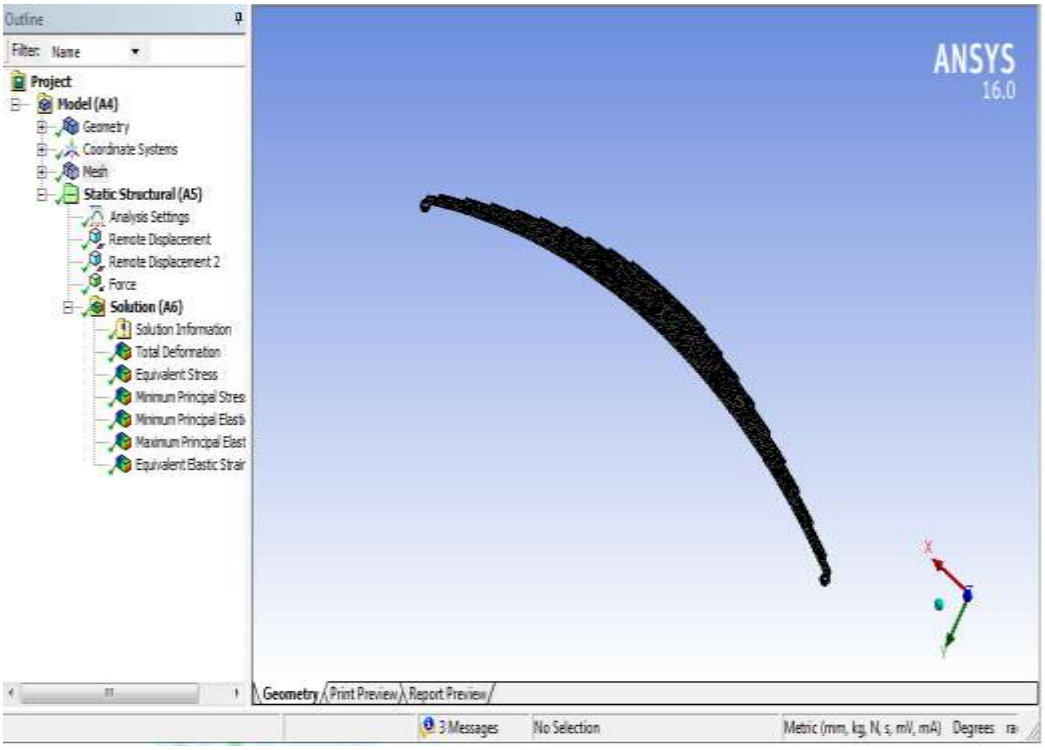


**Fig no 5.5: messing of leaf spring with 5mm dimensions**

 

**5.5.6 Apply boundary condition**

Boundary condition one end remote displacement for component X free, Y and Zfixed and rotation Z free, X and Y fixed and other end remote displacement forcomponent X, Y and Z fixed and rotation Z free, X and Y fixed. Loading conditionsinvolves applying a load upper side at the centre of the bottom leaf spring.

**5.5.7Results**

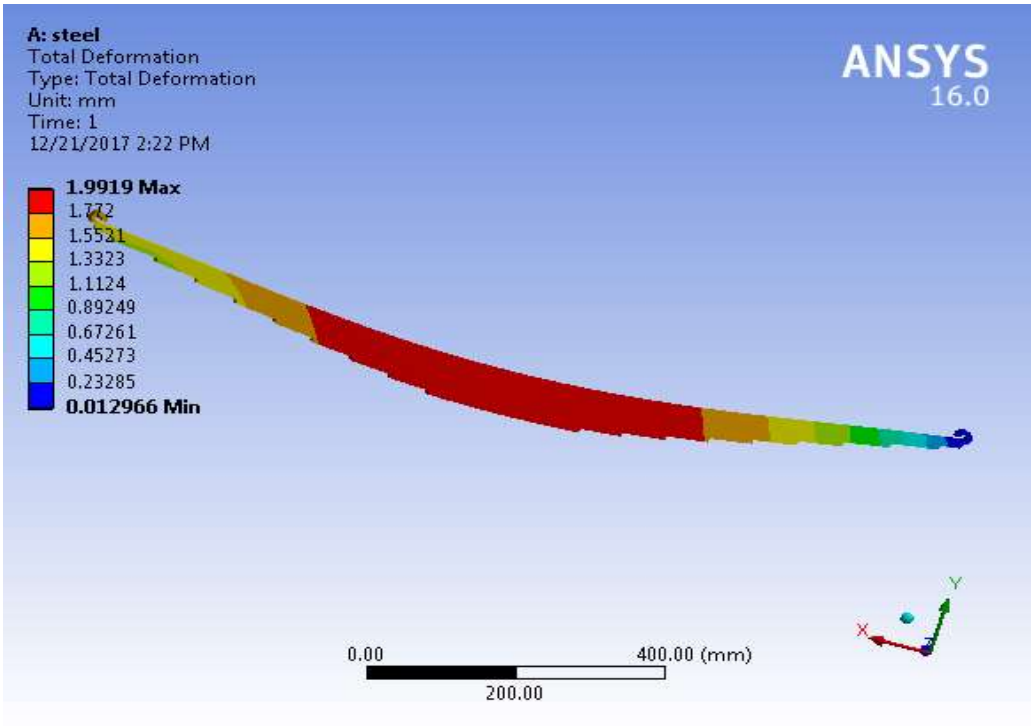


**Fig no5.5:total deformation for steel**

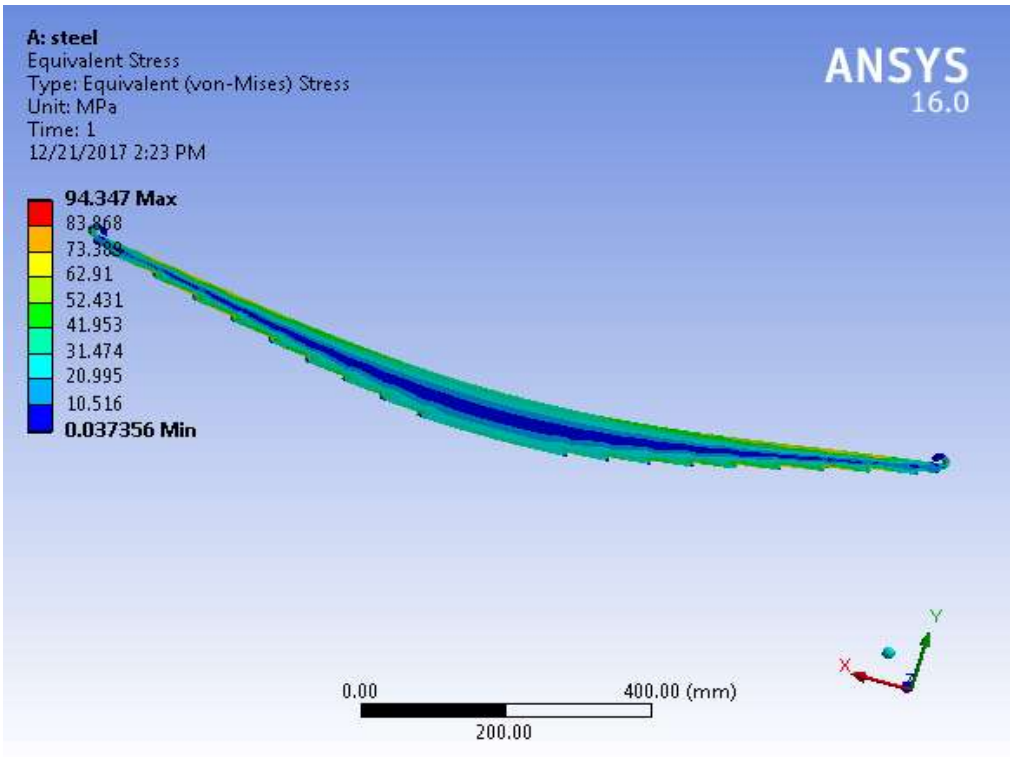


**Fig no 5.6:equivalent stress for steel**

 

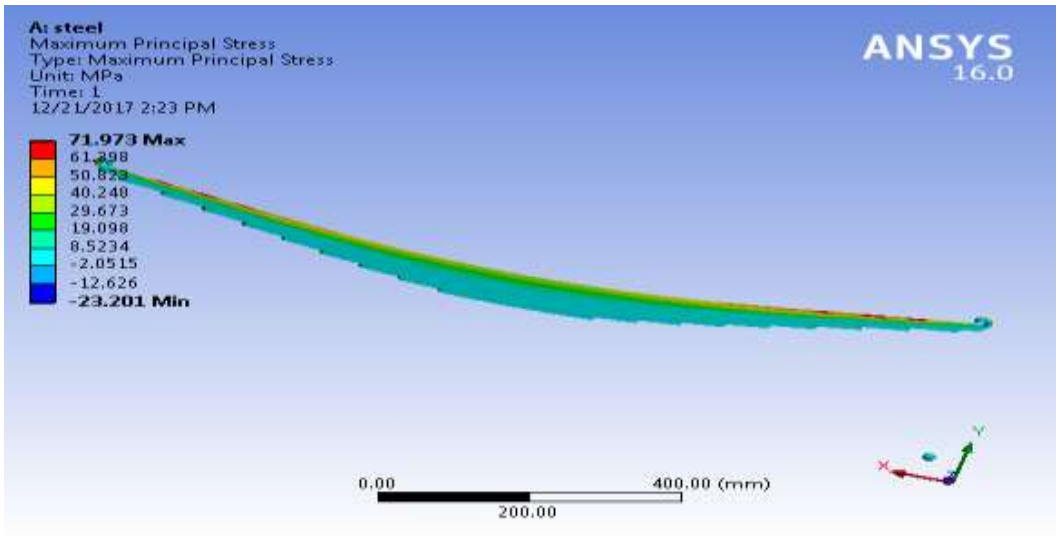


**Fig no 5.7:maximum principle stress for steel**

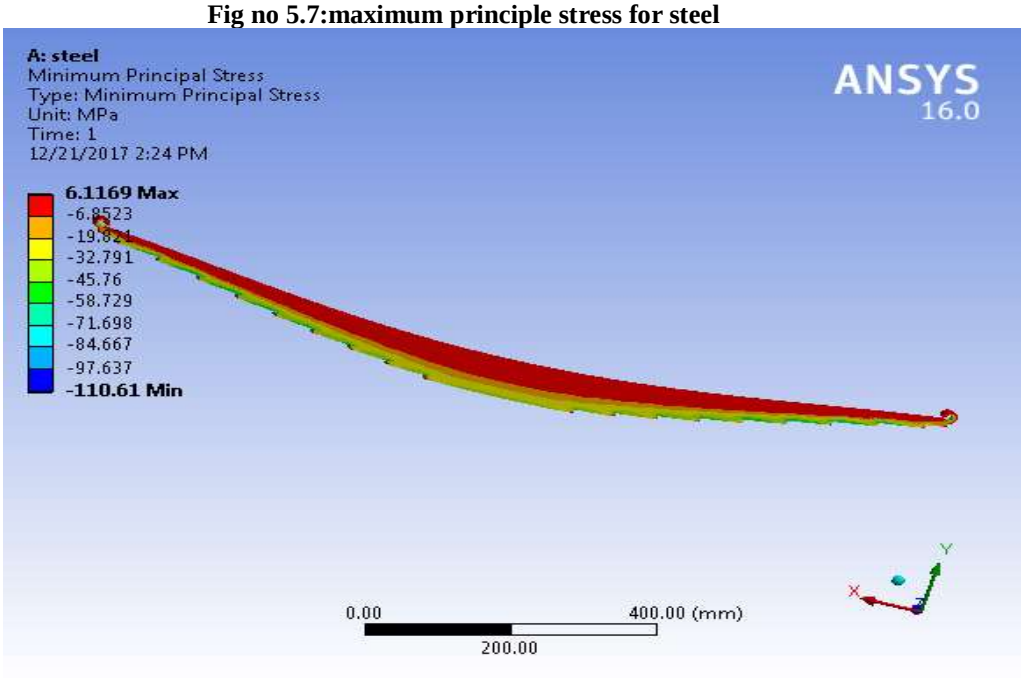


**Fig no 5.8:minimum principle stress for steel**

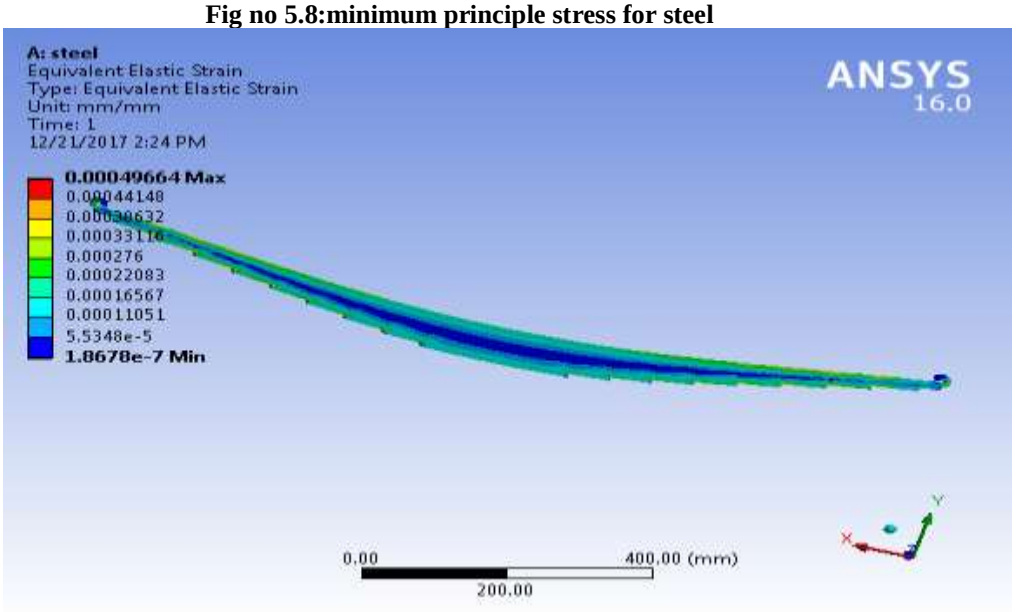


**Fig no 5.9:equivalent elastic strain for steel**

 

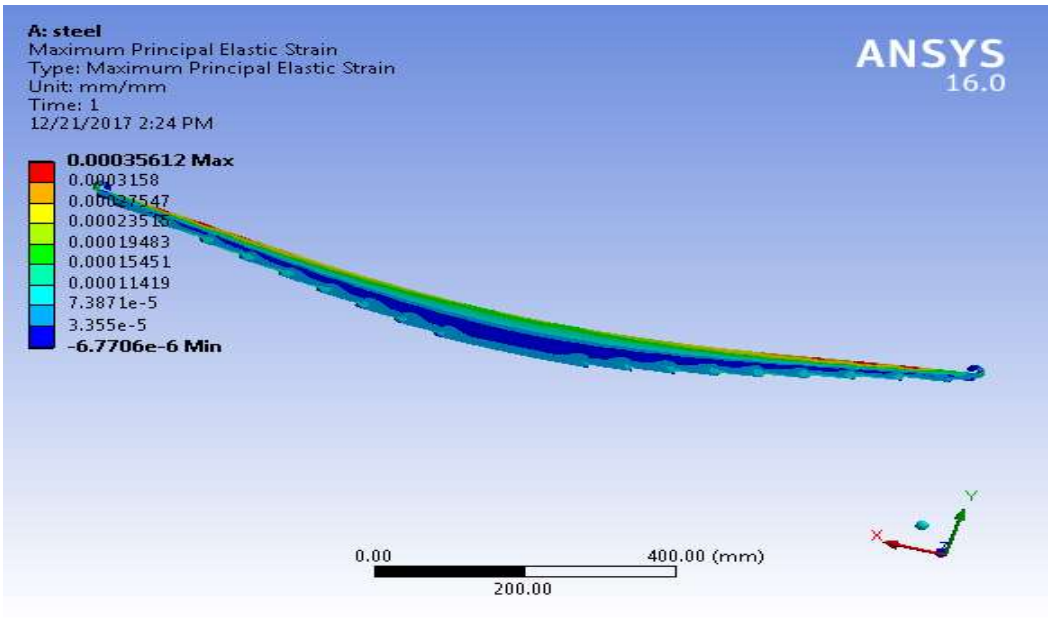


**Fig no 5.10:max principle strain for steel**

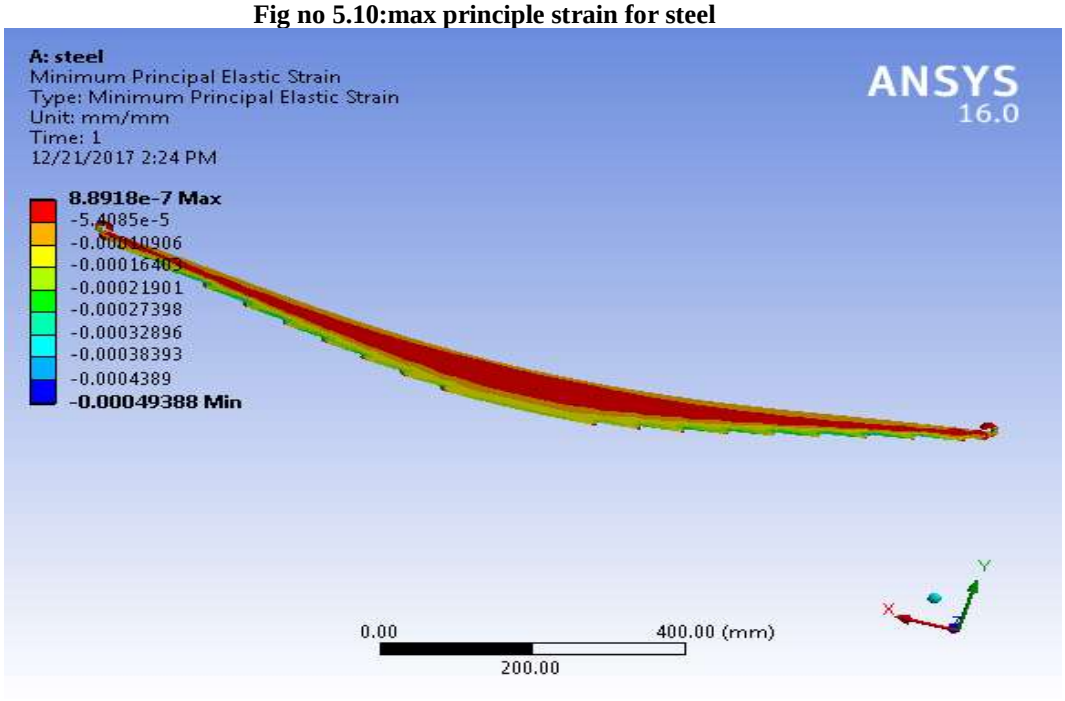


**Fig no5.11: minimum principle strain for steel**

**5.8 Result**

**Table no:5.1 result of steel and composite materiall**

| Sr no | Deformation(mm) | stress | Maximum strain |
|---|---|---|---|
| steel | 1.9919 | 71.97 | 0.0003 |
| glass epoxy | 12.87 | 73.82 | 0.0049 |
| Carbon epoxy | 6.54 | 75.65 | 0.004913 |

## I. CONCLUSION AND FUTURE SCOPE

**6.1Conclusion**

The usage of composite materials has resulted in considerable amount of weight saving when compared to conventional steel leaf spring. Taking into account the weight saving, deformation, shear stress induced and resultant frequency it is evident that composite has the most encouraging properties to act as replacement to steel

The .1present work was aimed at modification in suspension system of the automobiles in particular or any machine by reduction of weight, which employs leaf spring, in general. This was achieved by reducing the weight of the leaf spring with the use of composite materials.. Apart from being lightweight, the use of composites also ensures less noise and vibration.

 

**6.2 Future scope**

- Transient analysis of leaf spring
- Manufacturing of composite leaf spring.
- Experimental results for composite leaf spring.
- Residual stress calculation using FEA.

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