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Analysis of Leaf Spring Using Composite Material

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Abstract:

The suspension leaf spring is one of the potential items for weight reduction in automobile. This helps in achieving the vehicle with improved riding qualities. It is well known that springs, are designed to absorb and store energy and then release it.In this project design and analysis of leaf spring in heavy vehicle is carried out. The model of the leaf spring is designed using the software called pro E, and the systematic analysis of the designed model is done using ANSYS software.The model selected is rear leaf spring. In this model leaves are been used and material is used commonly for the leaf spring is spring steel. Now we are replacing the material to E glass epoxy. Then the model is analyzed for the deflection, max stress induced and strain for all the above materials under same load.

INTRODUCTION:

The leaf spring is one of the main components and it provides a good suspension and it plays a vital role in automobile application. It carries lateral loads, brake torque, driving torque in addition to shock absorbing. The advantage of leaf spring over helical spring is that the ends of the spring may be guided along a definite path as it deflects to act as a structural member in addition to energy absorbing device.The automobile industry is exploiting composite material technology for structural components in order to obtain the reduction of weight without decrease in vehicle quality and reliability. Energy conservation is one of the most important objectives in any vehicle design and reduction of weight is one of the most effective measures for energy conservation as it reduces overall fuel consumption of the vehicle. The suspension leaf spring is one of the potential items for weight reduction in automobiles as it accounts for ten to twenty percent of the unsprung weight. The leaf spring should absorb vertical vibrations, shocks and bump loads by means of spring deflection so that the potential energy is stored in the leaf spring as strain energy and then released slowly.

Thus elastic strain energy storage capacity is an important criterion while selecting the material for leaf spring . The specific elastic strain energy is inversely proportional to the density and young's modulus. The automobile industry has shown increased interest in the replacement of steel leaf spring with fiber glass composite leaf spring because FRP composites possess lower young's modulus, lower density and lesser weight as compared to steel. This research is an innovation in this field as it finds the suitability of natural fiber based hybrid composite material in leaf spring application. Recently natural fibers have been receiving considerable attention as substitutes for synthetic fiber reinforcements such as glass in plastics due to their low cost, low density, acceptable specific strength, fairly good mechanical properties, eco friendly and biodegradability characteristics.

Suspension can be considered as a link between the wheels and the body. It absorbs quick loadings and collects the elastic energy. Design fundamentals are based on the strength and comfort. The strength characteristics are usually determined according to the suspension type and loading. The comfort design fundamentals originate from the fluctuation and vibration point of view. The basic idea for the design is to generate the wanted elasticity and maintain the driving comfort. The leaf spring is one of the oldest suspension types. Nowadays it is widely used in heavy duty vehicles and work machines.The rear axle leaf is used in the suspension system of a vehicle. It is used to damp the vibration made by a vehicle on an irregular road. This provides safety to the engine and for transmission unit. It helps to drive the vehicle in a controlled manner.

The rear axle leaf spring is designed and all the strips are clamped using u-clamps. The spring is supported on the rear axle; one end of the spring is mounted on the frame using a simple pin the other end is connected with a shackle. The leaf spring is made up of steel.

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1.3 OBJECT AND SCOPE OF STUDY:

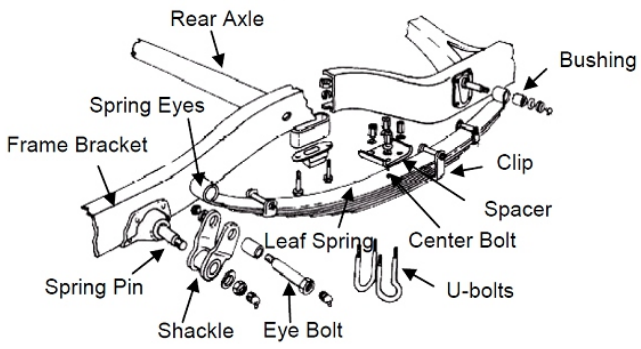
In this work, an attempt is made to develop a fiber reinforced composite material with optimum properties so that it can replace the existing steel material in automobile leaf spring application. Three dimensional models of leaf spring are prepared in PRO E. Static structural analysis of leaf spring models is performed in ANSYS 14.5 considering different materials i.e. steel and E-glass/Epoxy.

1.5 NEED FOR ANALYSIS:

Recently, automotive industry requires higher level of design and calculation almost in every part in both fabrication and testing which can make it possible to improve and develop products. Leaf spring, one of automotive parts, was mainly design based on trial-and-error techniques and simplified equations using a 3-link mechanism and beam theory for stress calculation

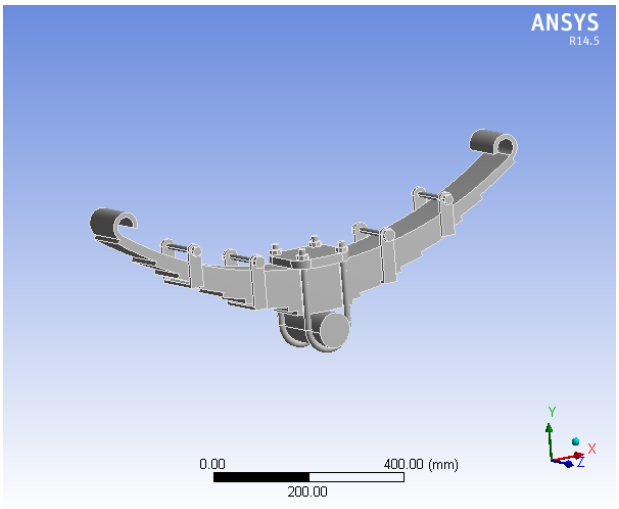
3.7 ANALYSIS PROCEDURE ANALYZING THE LEAF SPRING – STEP BY STEP PROCEDURE:

» The 3D model of the leaf spring is designed by Leaf spring, one of automotive parts, was mainly design based on trial-and-error techniques and simplified equations using a 3-link mechanism and beam theory for stress calculation.

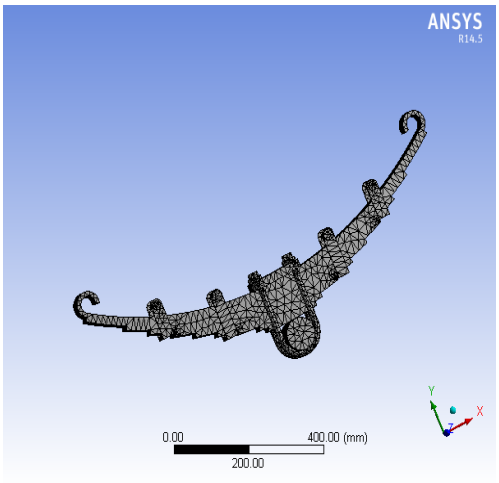


3.7 ANALYSIS PROCEDURE ANALYZING THE LEAF SPRING – STEP BY STEP PROCEDURE:

» The 3D model of the leaf spring is designed by using pro-e software and it is converted as IGES format.
» The IGES (Initial Graphic Exchange Specification) format is suitable to import in the ANSYS Workbench for analyzing
» Open the ANSYS workbench
» Create new geometry
» File – import external geometry file – generate



» Project – new mesh
» Defaults – physical preference – mechanical
» Advanced – relevance center – fine
» Right click the mesh in tree view – generate mesh



» Project – convert to simulation – yes
» Select the all solid in geometry tree
» Definition – material – new material
» New material – right click – rename – 60Si7 steel
» Enter the value of the young's modulus, poisons ratio, density and etc.
» New analysis – Static structural
» Static structural – right click – insert – fixed support
» Select the inner circular faces of the leaf spring
» Geometry – apply
» Static structural – right click - insert – force – select the face to define the force direction
» Geometry – apply

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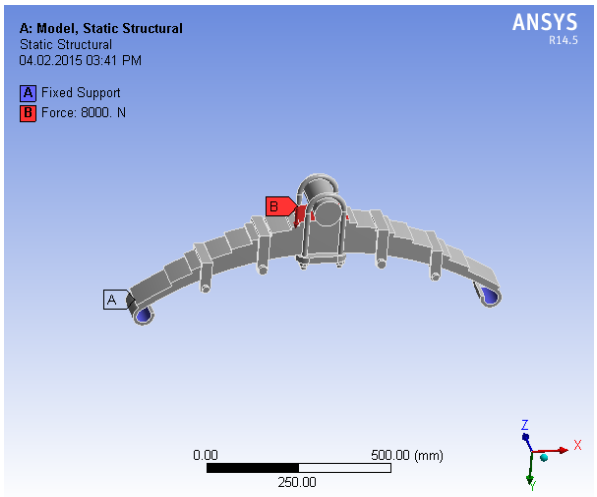
» Provide the value of the force to 8000N.
» Then define the solution
» Solution – right click - insert the total deformation, equivalent elastic strain, and equivalent stress.
» Right click the solution icon in the tree – solve
» Repeat the above steps for E glass epoxy composite.
» To capture the figure use the option new figure in tool bar.
» The all results are taken in a picture – and save it to the required folder in the system



CALCULATION

THEORETICAL CALCULATION FOR LEAF SPRING

DESIGN DATA:

Existing material

1)SPRING STEEL

Overall length of the leaf spring, 2 L = 1000 mm;
L = 500 mm
Total no. of leaves, n = 9
Load on the spring, P =8000N
No. of graduated leaves, n g = n - n f
= 9 – 1= 8 nos
Where, n f = No. of full length leaves
Width of the leaves, b = 90 mm
Thickness of the leaf t = 10 mm
E = Youngs modulus of material = 2.1 x 10^5 N/mm^2
Deflection of the spring, y = 18 P L 3/E b t 3 (3 n f + 2 n g)
= 18 x 8000 x 500^3 / 2.1 x 10^5 x 90 x 10^3 (3 x 1 + 2 x 8)
= 50.12 mm

MATERIAL PROPERTIES

5.1 60Si7 STEEL:

Young's modulus	2.1e5 MPa
Poisson's ratio	0.266
Density	7860 kg/m^3
Shear modulus	78989 MPa
Bulk modulus	1.4245e5 MPa

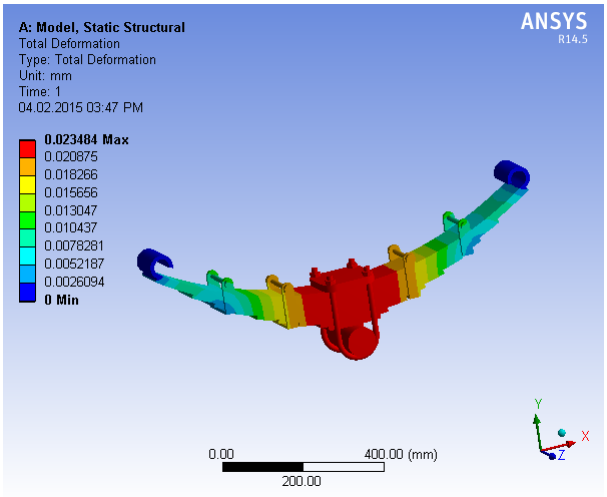
5.2 E GLASS/ EPOXY:

Young's modulus	24000 MPa
Poisson's ratio	0.3
Density	1520 kg/m^3
Shear modulus	28991 MPa
Bulk modulus	50484 MPa

RESULTS

6.1 RESULTS FOR 60Si7 STEEL

TOTAL DEFORMATION



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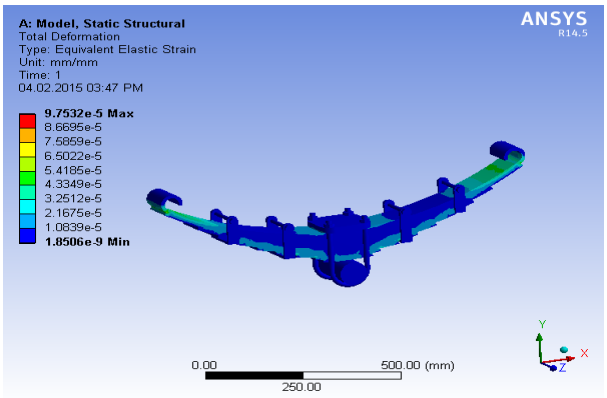
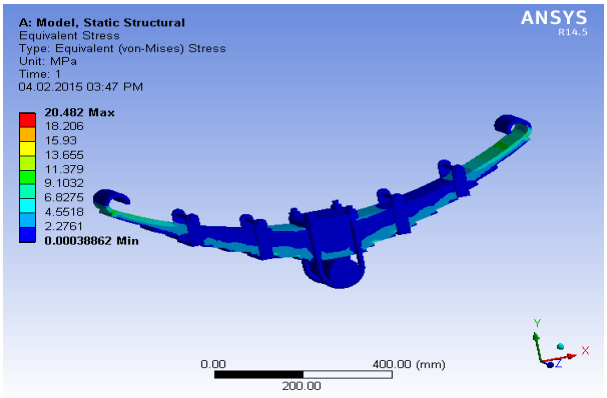
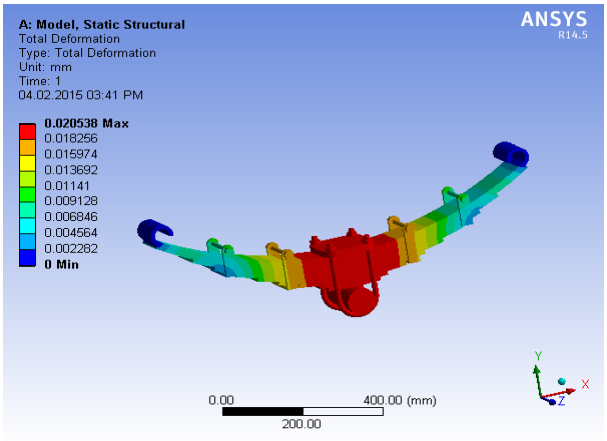
EQUIVALENT ELASTIC STRAIN



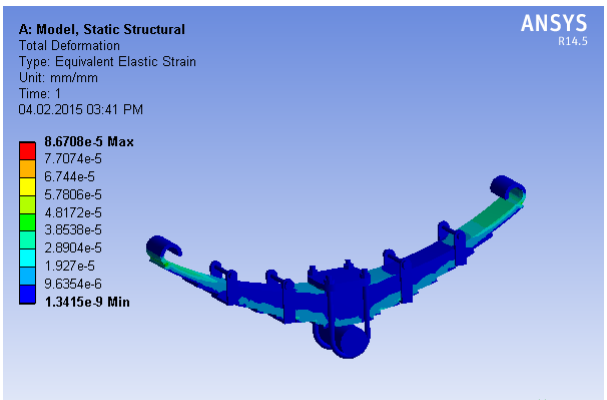
EQUIVALENT STRESS



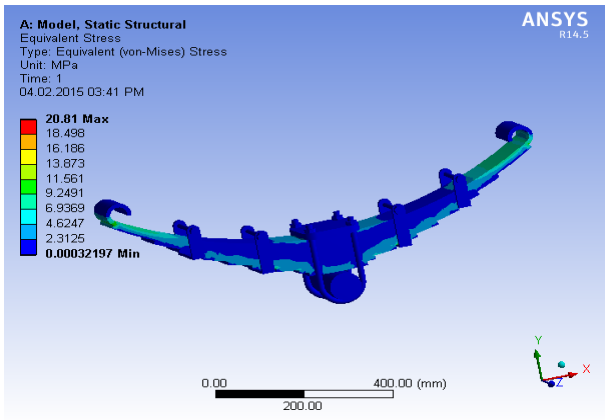
6.2 RESULTS FOR E GLASS EPOXY TOTAL DEFORMATION



EQUIVALENT ELASTIC STRAIN



EQUIVALENT STRESS



RESULT COMPARISION FOR 60Si7 STEEL

60Si7 STEEL	MINIMUM	MAXIMUM
Total deformation (mm)	0	0.02348
Equivalent elastic strain (mm/mm)	1.85e-9	9.753e-5
Equivalent stress (MPa)	3.88e-4	20.482

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RESULT COMPARISION OF E-GLASS EPOXY:

E-GLASS EPOXY	MINIMUM	MAXIMUM
Total deformation (mm)	0	0.0205
Equivalent elastic strain (mm/mm)	1.341e-9	8.671e-5
Equivalent stress (MPa)	3.22e-4	20.81

CONCLUSION:

Analyzing results for leaf spring under force are listed in the Table. Analysis has been carried out by 60Si7 steel (conventional material) and optimizing the materials i.e., E glass epoxy. The results such as total deformation, equivalent elastic strain and equivalent stress for each material are determined. Comparing the optimized materials and the conventional material, E glass epoxy composite material has the low values of total deformation and strain. While using E glass epoxy weight of the leaf is reduced by 67.69%. Hence it is concluded that E glass epoxy material can be used for the leaf spring.The project carried out by us will make an impressing mark in the field of automobile. While carrying out this project we are able to study about the 3Dmodelling software (PRO-E) and Study about the analyzing software (ansys) to develop our basic knowledge to know about the industrial design.

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