Design and Analysis of a Leaf Spring for Light Vehicle Mini Trucks

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Abstract: In the present scenario weight reduction is the main focus of an automobile manufacturer. Generally leaf spring is used for suspension purposes in light & heavy trucks. These springs are mainly made up of steel material which having more weight. In order to reduce the weight, here composite leaf spring is used instead of steel leaf spring.Composite materials are widely used in aeronautical, marine and automotive industries, because of their excellent mechanical properties, low density and ease of manufacture.Due to this increasing trend to utilize composite materials, it has become necessary to investigate the pros and cons of composites.Leaf springs are one of the oldest suspension components that are being still used widely in automobiles. They contribute to 15-20% unsprung weight. This work deals with the replacement of conventional steel leaf spring with composite leaf spring. Comparisonof steel and composite leaf spring usingANSYS Software. The the effects of change in design on the total deformation, equivalent elastic strain and equivalent stress was studied buy using ANSYS. The leaf spring is modeled Using CATIA for the four materials E glass epoxy, S glass epoxy, Kevlar epoxy and carbon fiber.

KEYWORDS: Leafspring, Composite materials, E glass epoxy, S glass epoxy, Kevlar epoxy, Carbon fiber.

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INTRODUCTION:

There is growing demand from the industries for the development of new concepts and approach to meet the new challenges in the field of manufacturing engineering. Some research and improvements are always necessary in the present level of technology to achieve the demands of modern industrial world and customers. The fatigue failure of leaf springs, strength and weight reduction are primary concern at present.This work has been done using computer aided engineering analysis which is based upon a mathematical technique called finite element method. The component chosen for this purpose is leaf springs which find widespread application in the suspension systems of automotive vehicles. Though several attempts were made to evaluate fatigue and fretting behavior of leaf springs using stress based and crack based approach but the present work is on the CAE analysis of leaf springs and then experimentally validation by stress based approach. The analysis is accomplished by adopting new technologies for production, modification in designs or replacing the existing materials with the newer ones having better properties. Computer aided engineering analysis of the leaf springs has been done and then validated through the results of experimental testing in manufacturing industry.

In many automobile components fatigue failure is the predominant mode of in-service failure. This is due to the automobile components are subjected to variety of fatigue loads such as shocks caused due to road irregularities, traced by the road wheels, the sudden loads due to the bumps on road etc. The leaf springs are more affected due to fatigue loads, as they are a part of the un-sprung mass of the automobile.

OBJECTIVES

The research described in this report had the following objectives:

- To Design and analysis of a leaf spring for light vehicle trucks.
- To propose comparison of conventional multi steel leaf spring, composite leaf sping have less weight, stresses, vibrations and increasing strength, fatigue life and better ride comfort.
- To develop the design theory of composite leaf springs which will enhance their applications in automobile industry and other mechanical systems.

RELATED WORK

There are numerous works that have been done related to design and analysis of a leafspring.

Mr.Abdul Rahim Abu Talib, Aidy Ali, G. Goudah, NurAzidaCheLah and A.F. Golestaneh[1]has worked on designing of a composite elliptical leaf spring for automotive applications. After that using this conclusion they have change steel leaf spring by composite material and analyze it with same loading condition. They concluded that composite elliptical springs have superior fatigue performance than steel.

Krishan Kumar, Aggarwal M.L[2]had done project on Various Design Parameters for steel Flat Leaf Spring. In the present work, they have optimized the of design parameters of flat leaf springs have been done keeping into account the reduction in the weight of components and increase in fatigue life at wide range of operating conditions.

Ghodake et al[3]worked on analysis of steel and composite leaf spring for vehicle. They have done3-D modeling of both the steel and composite leaf spring and analyzed. They have also done a comparative study made between composite and steel leaf spring with respect to Deflection , strain energy and stresses. They have concluded that the composite leaf spring is lighter and more economical than the conventional steel spring with similar design specifications.

T.Keerthivasanet al[4]Their main objective is to reduce weight of leaf spring by using alternative materials, like composite materials. Glass, carbon, Aramid fibers and Epoxy resin. The different specimens were prepared using Manual layup method, they are taken, for tensile and Impact test. They have compared all values which are tabulated. And concluded that composite leaf spring will provide better performance when compared to ordinary steel leaf spring.

Mr. MangeshAngadraoBidve, Dr. Manish Billore[5]Their main objective is to optimize and analyse a composite leaf spring for light weight vehicles. They have developed a design theory for composite leaf spring which will enhance the applications in automobile industries. They have concluded that their paper focuses only on the literature review of previously published studies.

Mayur D. Teli, Umesh S. Chavan, HaribhauG.Phakatkar[6]They have done a project on "Design, analysis and experimental testing of composite leaf spring for application in electric vehicle". They have conducted an experiment on TATA sumo leaf spring. T hey concluded that the glass fiber reinforced plastic leaf spring is better material and economical alternate of steel leaf spring for electric vehicle with excess battery weight for static conditions.

METHODOLOGY

- The leaf spring was modeled in CATIA V5 and the analysis was done using ANSYS R16.2 software.
- Finite element model was prepared in catia.
- The finite element model was imported to ansys work bench.
- Hyper mesh software is used to create mesh.
- Tetrahedron mesh done on leaf spring geometry.
- Applying material properties.
- Applying boundary conditions.
- Applying load.
- Solution of maximum deformation is observed.
- Solution of maximum equivalent stress is observed.
- Solution of maximum equivalent strain is observed.

Process Description

The desing model of leaf spring is done in catia part design.

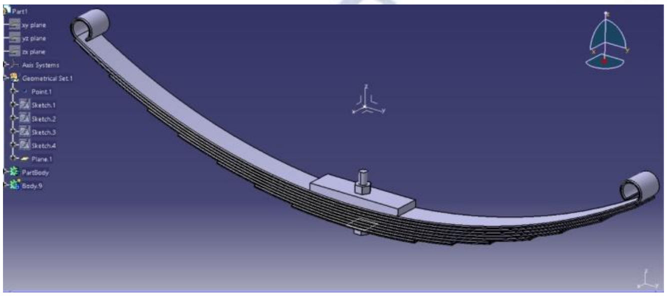

Fig-1: Catia part desing of leaf spring

Modeling

For creating a new static structural analysisthe geometry is imported in to the mechanical window. For doing the analysis on the whole leaf spring, as it is an assembly of number of leaves and nut and bolt, the leaf spring is considered to be a single body. It has two eye ends. The Cartesian co ordinates system has to be defined. Rename the co ordinates system as cso01. The geometry reference is required to define the coordinate system. Geometry surface is selected in the selection filter, pick the first cylindrical surface. Since it is Cartesian co-ordinates systemrenameas cso02 .The geometry of the new co ordinate system is replaced by the other end of the cylindrical surface. Geometry surface is selected in the selection filter, pick the second cylindrical surface. Currently three co ordinate system occurs.

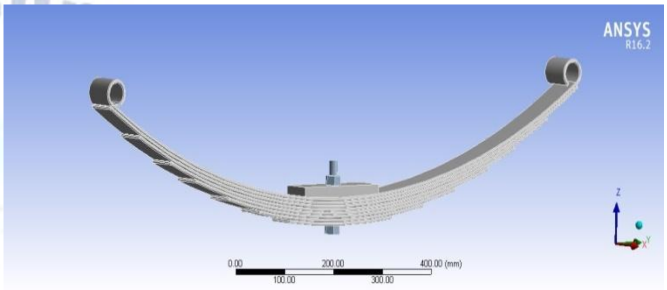

Fig-2: Model of leaf spring

After importing the model the required material is applied. For applying the material the properties of materials should be imported like young's modules from the library option.

Meshing

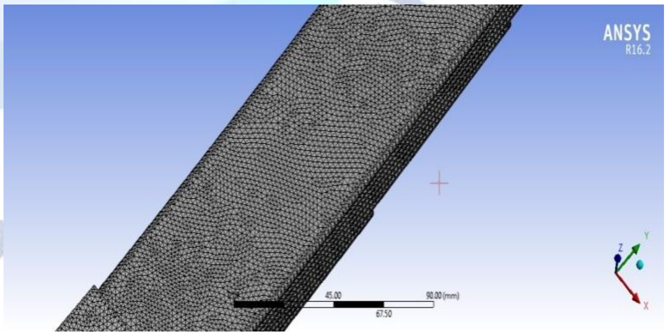

Fig-3: Meshing of leaf spring

- After applying the material to the model, meshing should be done.
- Mesh > insert > seizing. All the faces should be seized with the element sizes of 100mm. Select span angle center as Fine and smoothing as high and make sure that the surface is selected in the selection filter.

Select all, this will select the surfaces on the leaf springs then apply.

- Mesh > generate mesh. It will processes for a few minutes to update.

Application of load

The load of 80000 N is applied on the leaf spring.

Conventional leaf spring

Table -1: Material properties of spring steel

Denisity	7.83e-006 kg/mm³
Young modulus MPa	2.04e+005
Poisson's ratio	0.3

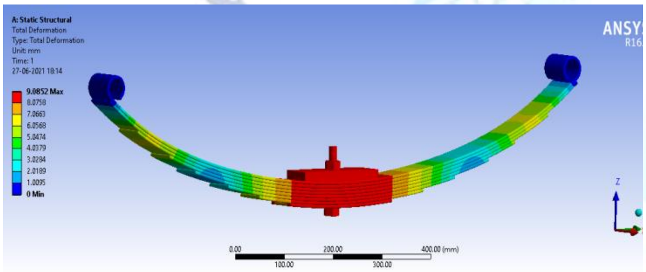

Fig-4: Total deformation of conventional steel leaf spring

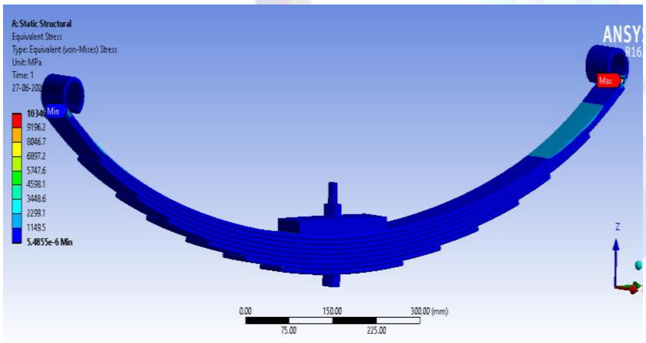

Fig-5: Equivalent stress

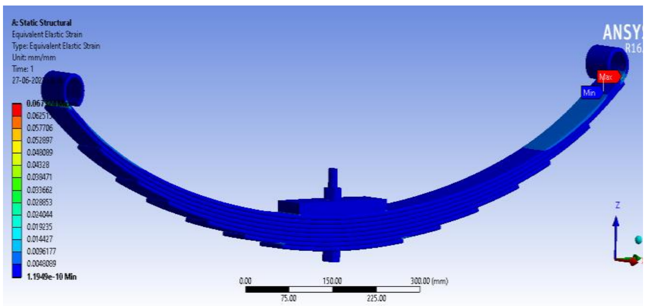

Fig-6: Equivalent elastic strain

Table -2:conventional leaf spring result

Conventional spring	Minimum	Maximum
Total deformation	0	9.0852
Equivalent elastic strain	1.1949e-10	0.067324
Equivalent stress	5.4855e-6	10346

Carbon fiber leaf spring

Table -3: Material properties of carbon fiber

Density	6.3e-018 tonne mm^-3
Young modulus MPa	2.75e+005
Poisson's ratio	0.34
Bulk modulus MPa	2.8646e+005
Shear modulus MPa	1.0261e+005

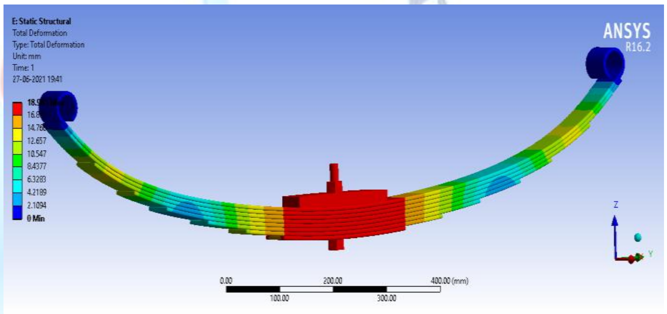

Fig-7: Total deformation of carbon fiber leaf spring

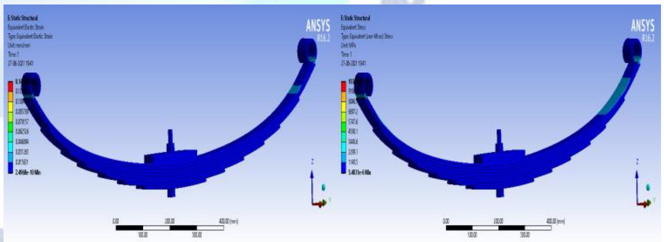

Fig -8: Equivalent Elastic Strain. **Fig-9:** Equivalent Stress

Table-4: Carbon fiber leaf spring result

Carbon fiber	Minimum	Maximum
Total deformation	0	18.985
Equivalent elastic strain	2.4968e-10	0.14068
Equivalent stress	5.4831e-6	10346

E glass epoxy leaf spring

Table-5: Material properties of E glass epoxy

Density	2.6e-018 tonne mm^-3
Young modulus MPa	6530
Poisson's ratio	0.217
Bulk modulus MPa	3845.7
Shear modulus MPa	2682.8

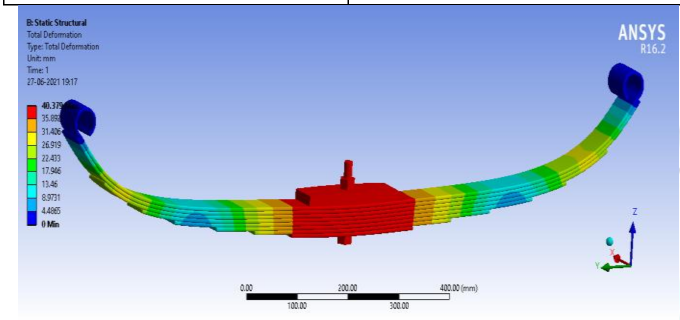

Fig -10: Total deformation of E glass epoxy leaf spring

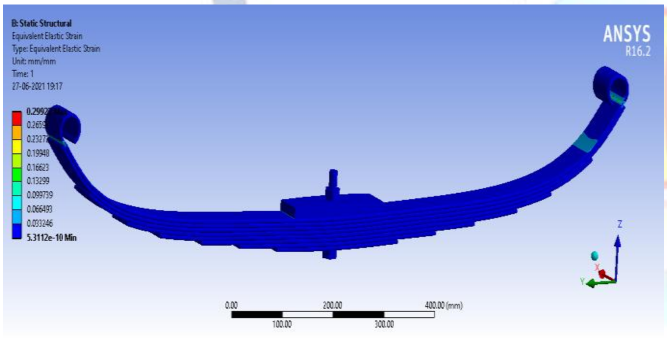

Fig -11: Equivalent elastic strain

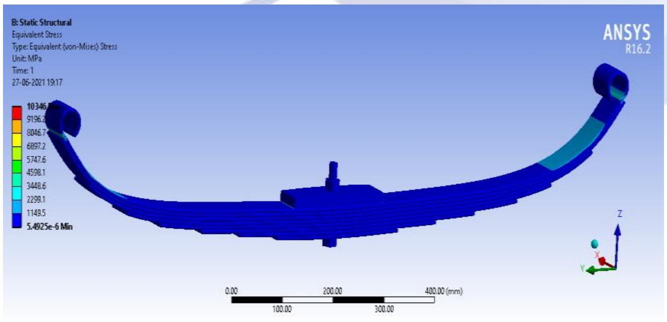

Fig -12: Equivalent stress

Table -8: E glass epoxy leaf spring –result

E GLASS EPOXY	Minimum	Maximum
Total deformation	0	40.379
Equivalent elastic strain	5.3112e-10	0.29922
Equivalent stress	5.4925e-6	10346

S glass epoxy leaf spring

Table-9: Material properties of S glass epoxy

Density	2.4e-018 tonne mm^-3
Young modulus MPa	6530
Poisson's ratio	0.3
Bulk modulus MPa	1700
Shear modulus MPa	1000

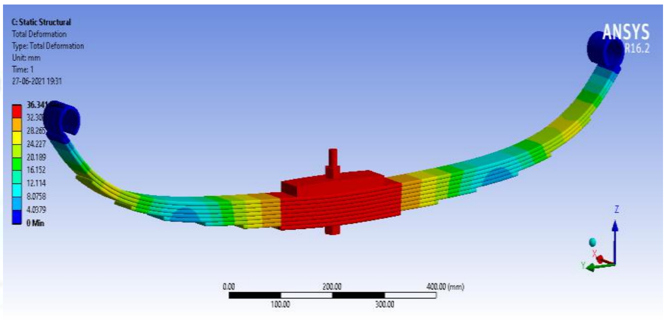

Fig -13: Total deformation of S glass epoxy leaf spring

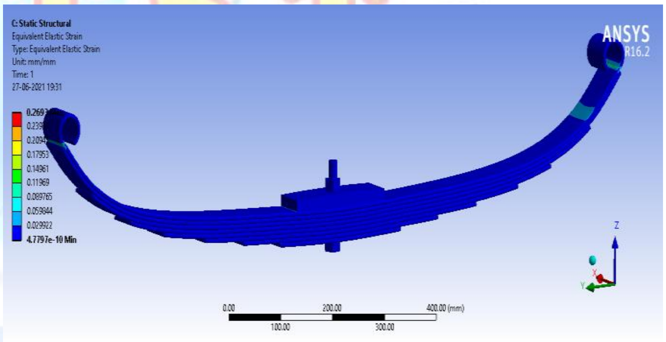

Fig -14: Equivalent elastic strain

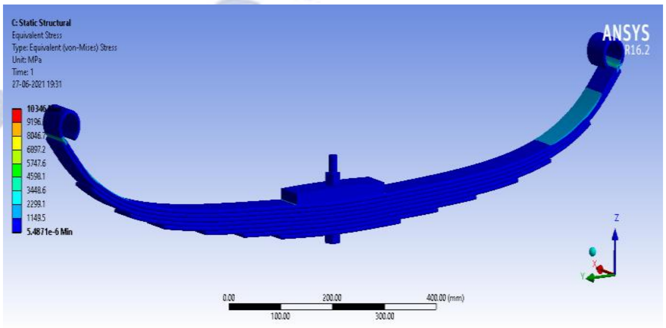

Fig -15: Equivalent stress

Table -10:S glass epoxy leaf spring –result

S GLASS EPOXY	Minimum	Maximum
Total deformation	0	36.341
Equivalent elastic strain	4.7797e-10	0.2693
Equivalent stress	5.4871e-6	1.346

Kevlar epoxy leaf spring

Table-11: Material properties of Kevlar epoxy

Density	1.4e-018 tonne mm^-3
Young modulus MPa	95710
Poisson's ratio	0.34
Bulk modulus MPa	1600
Shear modulus MPa	2682.8

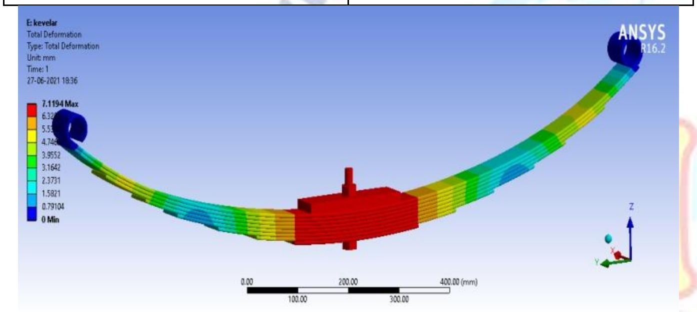

Fig -16: Total deformation of Kevlar epoxy leaf spring

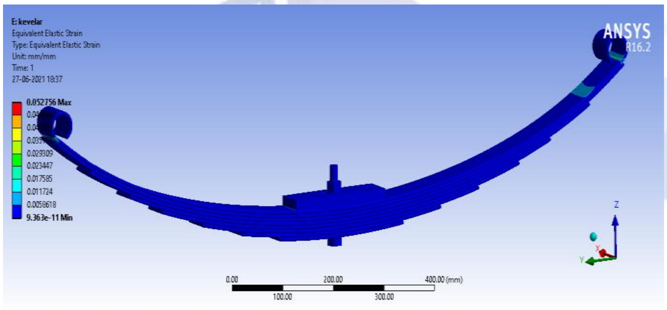

Fig -17: Equivalent elastic strain

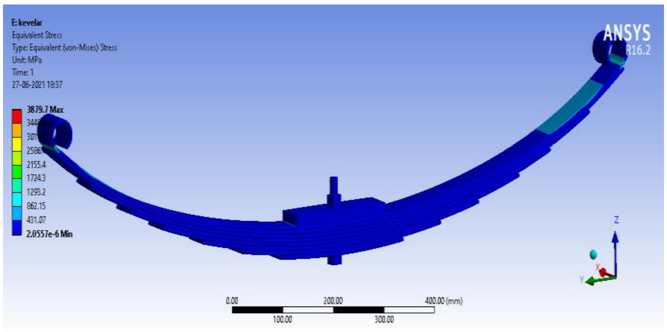

Fig -18: Equivalent stress

Table -12: Kevlar epoxy leaf spring –result

Kevlar EPOXY	Minimum	Maximum
Total deformation	0	7.1194
Equivalent elastic strain	9.363e-11	0.052756
Equivalent stress	2.0557e-6	3879.7

Table-13: Result comparison of all leaf springs

leafspring type	Total deformation	Equivalet elastic strain	Equivalent stress
conventiona	9.0852	0.067324	10346
carbon fiber	18.985	0.14068	10346
E glass epoxy	40.379	0.29922	10346
S glass epoxy	0.29922	0.2693	1.346
kevlar	7.1194	0.052756	3879.7

FUTURE SCOPE AND CONCLUSION

A comparative study has been made between conventional multi leaf steel spring and composite leaf spring of S glass epoxy, carbon fiber, E glass epoxy, Kevlar epoxy with respect to deflection. Among these E-glass epoxy has the better deformation. Composite leaf spring reduces the friction co efficient and wear rate and increase the strength, fatigue life by over conventional multi leaf steel spring.

A comparative study has been made between steel and composite leaf spring with respect to strength and weight. Composite leaf spring reduces the weight by 67.88% for EGlass/Epoxy.

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