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Vehicle Leaf Spring Design, Analysis & Comparison by Using E-Glass / Epoxy and Steel 65Si7

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Abstract
The fundamental Objective of this project is to represent plan and exploratory examination of composite leaf spring made of glass fiber reinforced polymer. The intention is to look at the load carrying capacity, weight and stiffness effective of composite leaf spring with that of steel leaf spring. The design imperatives are stresses and deflections. The measurements of a current ordinary steel leaf spring of a light business vehicle are taken. Static investigation of leaf spring is likewise performed utilizing analysis software and compared with experimental results. Limited component investigation with full load on 3D model of composite multi leaf spring is done utilizing analysis software and the analytical results are compared with experimental results.
Keywords: *Leaf Spring, Steel 65Si7, E-Glass/Epoxy Material, Automobile.*

1. Introduction

Leaf springs are essentially utilized as a part of suspension systems to absorb shock loads in automobiles like light engine vehicles, Heavy trucks and SUV Cars. It conveys sidelong loads, brake torque, driving torque in addition to shock absorber. The benefit of leaf spring over helical spring is that the finishes of the spring might be guided along a positive way as it diverts to go about as an auxiliary part not withstanding vitality retaining tool. As indicated by the reviews made a material with greatest quality and least modulus of flexibility in the longitudinal course is the most reasonable material for a leaf spring. To address the issue of regular assets protection, car producers are endeavoring to diminish the heaviness of vehicles as of late. Weight lessening can be accomplished fundamentally by the presentation of better material, outline advancement and better assembling forms. The suspension leaf spring is one of the potential things for weight decrease in vehicles un-sprung weight. This accomplishes the vehicle with more fuel effectiveness and enhanced riding qualities. The presentation of composite materials was made it conceivable to lessen the heaviness of leaf spring with no decrease on load conveying limit and solidness.

For weight diminishment in cars as it prompts to the decrease of un-sprung weight of car. The components whose weight is not transmitted to the suspension spring are known as the un-sprung components of the car. This incorporates wheel get together, axles, and part of the heaviness of suspension spring and safeguards. The leaf spring represents 10-20% of the un-sprung weight. The composite materials made it conceivable to diminish the heaviness of machine component with no lessening of the heap conveying limit. On account of composite material's high flexible strain vitality stockpiling limit and high quality to-weight proportion contrasted and those of steel. FRP springs likewise have superb weariness resistance and sturdiness. However, the weight lessening of the leaf spring is accomplished by material substitution as well as by outline enhancement. Weight diminishment has been the principle center of car makers in the present situation. The supplanting of steel with ideally planned composite leaf spring can give 92% weight lessening. In addition the composite leaf spring has bring down burdens contrasted with steel spring. All these will bring about fuel economical which will make nations energy free on the surroundings that fuel saved is fuel produced.

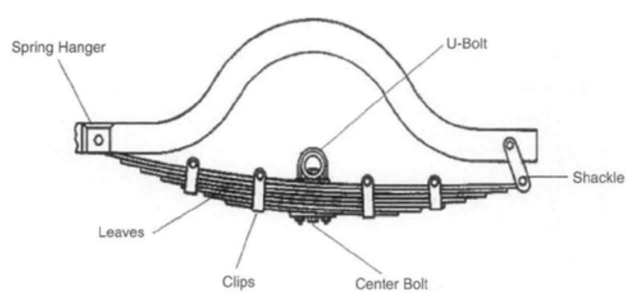

Fig.1 Leaf Spring

2. Design & Analysis
In order to research relationship between stiffness, mass and design variables, and common batch file is built by 3D modeling software and analysis is done in Analysis / simulation Software.

2.1 Design Selection

The leaf spring carries on like a just upheld pillar and the flexural investigation is done considering it as a basically bolstered shaft. The just bolstered shaft is subjected to both twisting anxiety and transverse shear stretch. Flexural unbending nature is a vital parameter in the leaf spring plan and test out to increment from two finishes to the middle.

Constant Thickness, Varying Width Design: In this plan the thickness is kept steady over the whole length of the leaf spring while the width differs from a base at the two finishes to a greatest at the middle.

Constant Width, Varying Thickness Design: In this plan the width is kept steady over the whole length of the leaf spring while the thickness changes from a base at the two finishes to a most extreme at the inside.

Constant Cross-Selection Design: In this plan both thickness and width are changed all through the leaf spring with the end goal that the cross-segment zone stays steady along the length of the leaf spring. Out of the previously mentioned plan ideas. The steady cross-area plan strategy is chosen because of the accompanying reasons: Due to its capacity for large scale manufacturing and settlement of persistent support of filaments.

Since the cross-segment zone is steady all through the leaf spring, same amount of support fiber and resin can be encouraged constantly amid produce. Additionally this is very reasonable for fiber winding procedure.

2.2 Objective

The objective of this project is as follows:

Analyze the load conveying limit, stresses, deflection and weight reserve saving of composite leaf spring with that of steel leaf spring.

The concentrated on the execution of composite materials by supplanting steel in routine leaf springs of a suspension system to reduce product weight, improving the safety, comfort and durability.

The 3-D displaying of both steel and composite leaf spring is done and analyzed. A relative review has been made amongst composite and steel leaf spring concerning Deflection, strain energy and stresses. From the outcomes, it is watched that the composite leaf spring is lighter and more temperate than the traditional steel spring with comparative outline details. It is watched that the weight diminishment of mono leaf spring is accomplished up 84.94% in the event of composite than steel.

The improvement of a composite leaf spring having consistent cross sectional territory, where the anxiety level at any station in the leaf spring is viewed as steady because of the allegorical kind of the thickness of the spring, has turned out to be exceptionally viable.

3. Material Selection

3.1 Materials for Steel leaf spring

First the material selected for leaf spring is Steel 65Si7. The design parameters selected for steel leaf are listed in table 1 & 2. The normal static loading is 2500 N and Number of leaves are 7 which is clamped with rectangular clamp.

Table. 1 Design Details of multi leaf spring

Length X	1226.1 mm
Length Y	291.68 mm
Length Z	111. mm
Space width of leaf spring	50 mm
Nodes	2972
Elements	527

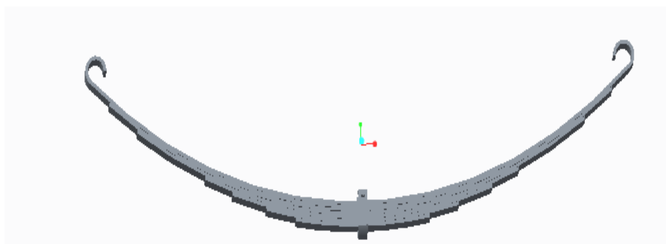

Fig.2 Design of leaf Spring

Table. 2 Stainless Steel > Constants

Density	7.75e-006 kg mm^-3
Coefficient of Thermal Expansion	1.7e-005 C^-1
Specific Heat	4.8e+005 mJ kg^-1 C^-1
Thermal Conductivity	1.51e-002 W mm^-1 C^-1
Resistivity	7.7e-004 ohm mm

3.2 Materials for Composite leaf spring

The greatest advantage, be that as it may, is mass decrease: Composite leaf springs are up to five circumstances more strong than a steel spring, a transverse composite leaf spring presses against the lower arm and traverses the width of the auto. Truth be told, the spring is constantly stacked against the sub outline. Composites additionally can possibly supplant steel and spare weight in longitudinal leaf springs.

Table. 3 E-Glass/Epoxy Material

Density	2.6e-006 kg mm^-3
Young's Modulus MPa	85000
Poisson's Ratio	0.23
Bulk Modulus MPa	524691
Shear Modulus MPa	34553
Tensile Yield Strength MPa	2050
Compressive Yield Strength MPa	5000

3.3 Design and meshing of spring

The design of leaf spring is done in 3D modeling software.

Fig. 3 Design of leaf spring

Mesh generation is the practice of generating a polygonal or polyhedral mesh or we say that it is the discretization of object into the small parts so that to get approximates a geometric domain

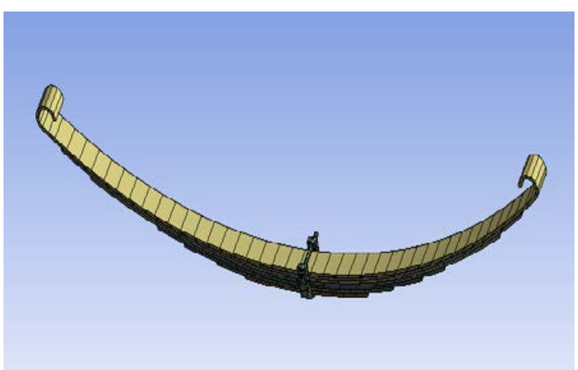

Fig.4 Meshing of spring

3.4 FEA (Finite Element Analysis)

FEA instrument is the numerical romanticizing of genuine framework. Is a PC based technique that breaks geometry into component and connection a progression of condition to every, which are then explained at the same time to assess the conduct of the whole framework. It is helpful for issue with confused geometry, stacking, and material properties where correct scientific arrangement are hard to acquire. Regularly utilized for basic, warm, liquid examination, yet generally material for other kind of investigation and reproduction.

Limited Element examination instruments offer the enormous favorable position of empowering configuration groups to consider for all intents and purposes any trim alternative without bringing about the cost connected with assembling and machine time.

The Ability to attempt new outlines or ideas on the PC gives the chance to dispense with issues before starting creation. Also, fashioners can rapidly and effectively decide the affectability of particular embellishment Parameters on the quality and creation of the last part. The distinctive relative aftereffects of steel leaf spring and composite leaf spring are acquired to anticipate the upsides of composite leaf spring for a vehicle.

3.5 Specification of the problem

The goal of the present work is to configuration, investigations, Glass Fiber/Epoxy finish composite leaf spring without end joints and composite leaf spring utilizing reinforced end joints utilizing hand-layup system. This is an option, proficient and efficient strategy over wet filament winding system.

Leaf springs otherwise called flat spring are made out of flat plates. Leaf springs are composed two ways: multi-leaf and mono-leaf. The leaf springs may convey loads, brake torque, driving torque, and so forth, Anyhow shocks. The multi-leaf spring is made of a few steel plates of various lengths stacked together. Amid ordinary operation, the spring packs to ingest street stun. The leaf springs twist and slide on each other permitting suspension development.

4. Methodology/ Planning of work

The whole analysis process shall begin with following steps: model definition, meshing, model analysis, validation of the Finite Element Analysis (FEA) model,

The process is briefed stepwise.

1) **Design of leaf spring**: The first step in the process is to define the model geometry. This is done by prepare a 3D solid modeling through using a computer-aided engineering tool.

2) **Importing solid model data into mesh model**: The second step is to import the data from the 3D solid model to the mesh generation software. This is done by creating a mesh model of the solid model after importing all the data into advanced analysis software and mesh generating tool.

3) **Finite Element Analysis (FEA) starts**: The finite element analysis was carried out using a commercial finite element analysis software package.
4) **Evaluations of the post processed results**: The results are post processed into a form suitable for engineering assessment

4.1 Analysis using Steel 65Si7

Load is acting 2500N on leaf spring.

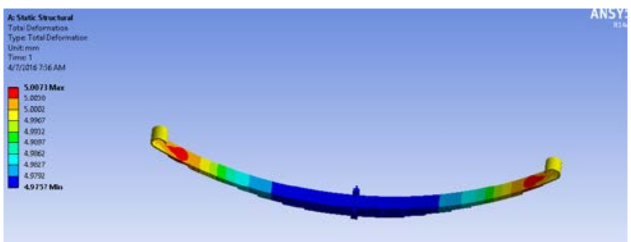

Fig.5 Total Deformation

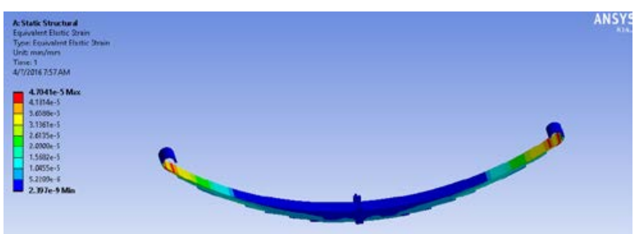

Fig.6 Equivalent Elastic Strain

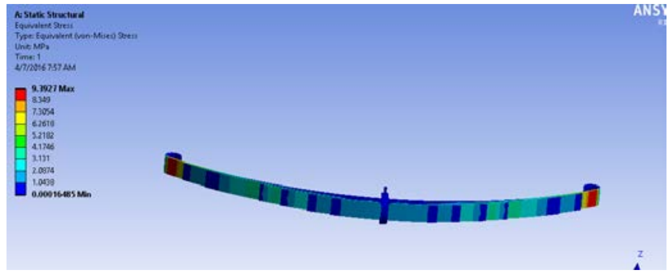

Fig.7 Equivalent stress

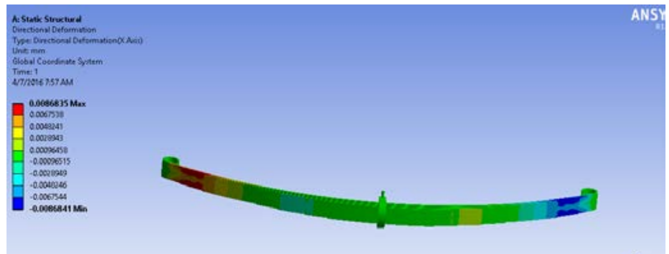

Fig.8 Deformation

Material details

Table. 4 Stainless Steel > Constants

Density	7.75e-006 kg mm^-3
Coefficient of Thermal Expansion	1.7e-005 C^-1
Specific Heat	4.8e+005 mJ kg^-1 C^-1
Thermal Conductivity	1.51e-002 W mm^-1 C^-1
Resistivity	7.7e-004 ohm mm

Table. 5 Stainless Steel > Compressive Yield Strength

Compressive Yield Strength MPa
207

Table. 6 Stainless Steel > Tensile Yield Strength

Tensile Yield Strength MPa
207

Table. 7 Stainless Steel > Tensile Ultimate Strength

Tensile Ultimate Strength MPa
586

Table. 8 Stainless Steel > Isotropic Elasticity

Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
1.93e+005	0.31	1.693e+005	73664

Loads on leaf spring

Table. 9 Static Structural > Loads

Object Name	Force
State	Fully Defined
Scope	
Scoping Method	Geometry Selection
Geometry	1 Face
Definition	
Type	Force
Define By	Vector
Magnitude	2500. N (ramped)
Direction	Defined
Suppressed	No

Solution/Result

Table. 10 Model > Static Structural > Solution > Results

Object Name	Total Deformation	Equivalent Elastic Strain	Equivalent Stress	Directional Deformation
Minimum	4.9749 mm	2.5162e-009 mm/mm	1.6125e-004 MPa	-8.9841e-003 mm
Maximum	5.0075 mm	4.8718e-005 mm/mm	9.3856 MPa	8.9844e-003 mm

4.2 Analysis using Composite Material "E-Glass/Epoxy"

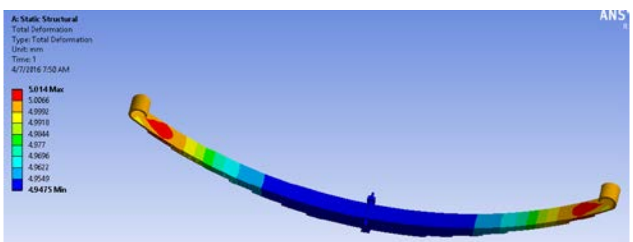

Fig.9 Total deformation

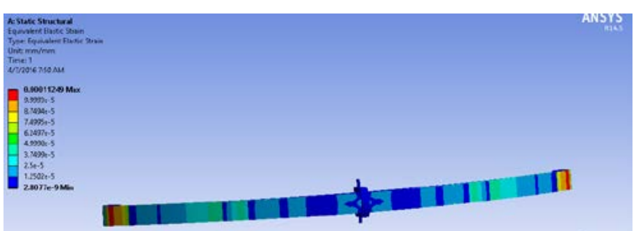

Fig.10 Equivalent elastic strain

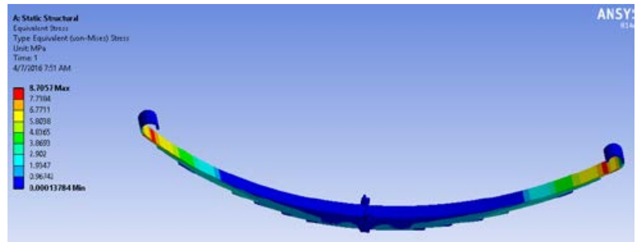

Fig.11 Equivalent stress

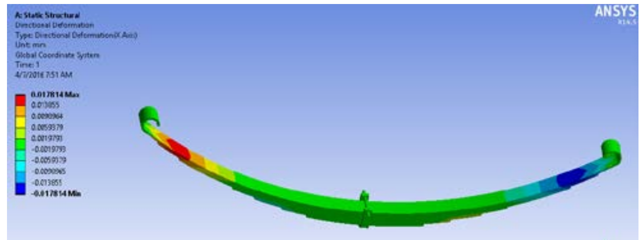

Fig.12 Deformation

Material Data

Table. 11 E-Glass/Epoxy > Constants

Density	2.6e-006 kg mm^-3

Table. 12 E-Glass/Epoxy > Isotropic Elasticity

Temperature C	Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
	85000	0.23	52469	34553

Table. 13 E-Glass/Epoxy > Tensile Yield Strength

Tensile Yield Strength MPa
2050

Table. 14 E-Glass/Epoxy > Compressive Yield Strength

Compressive Yield Strength MPa
5000

Solution/Results

Table. 15 Model > Static Structural > Solution > Results

Object Name	*Total Deformation*	*Equivalent Elastic Strain*	*Equivalent Stress*	*Directional Deformation*
Minimum	*4.9477 mm*	*2.5584e-009 mm/mm*	*7.067e-005 MPa*	*-1.7705e-002 mm*
Maximum	*5.0139 mm*	*1.125e-004 mm/mm*	*8.6738 MPa*	*1.7705e-002 mm*

5. Conclusions

Design & Analysis of both steel and material is done Analysis and simulation software.

It observe that steel leaf springs are approximate 70% heavier as compare to composite springs. A comparative study on both analysis & focusing on its equivalent Strain, von- misses Stress and its total deformation we get the results that composite spring is lighter and more economical as compare to steel spring on a same design.

The biggest benefit, is mass reduction, Composite leaf springs are up to 5 times more durable than a conventional steel spring.

5.1 Future Scope & benefits

1. Automobile industries research on reducing weight and increasing strength of products, so they were using such type of spring.
2. By design, leaf springs absorb vertical vibrations caused by irregularities in the road.
3. Weight saving as compare to Aluminum, Steel leaf springs.
4. Internal damping in the composite material leads to better vibration energy absorption within the material, resulting in reduced transmission of vibration noise to neighboring structures.

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