DESIGN AND STRUCTURAL ANALYSIS OF LEAF SPRING USING OF ANSYS

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Abstract

A leaf spring is a simple form of spring, commonly used for the suspension in wheeled vehicles. Leaf springs are long and narrow plates attached to the frame of a trailer that rest above or below the trailer's axle. For safe and comfortable riding, to prevent the road shocks from being transmitted to the vehicle components and to safeguard the occupants from road shocks it is necessary to determine the maximum safe stress and deflection. The objective is to find the stresses and deformation in the leaf spring by applying static load on it. Different materials with different mechanical properties are considered for the structural static analysis. Therefore in the present work, leaf spring is designed by considering static load on vehicle. The model of leaf spring is created in solid works with three different thickness 4mm, 5mm and 6mm and analysis is done using ansys 14.5 workbench with three different materials such as Carbon epoxy, Carbon steel E-glass epoxy. Thus the structural analysis is carried out at 6685N force and stress, strain, maximum shear stress and total deformation values found out.

Introduction

A leaf spring is a simple form of spring commonly used for the suspension in wheeled vehicles. Originally called a laminated or carriage spring, and sometimes referred as semi-elliptical spring or cart spring, it is one of the oldest forms of springing, dating back to medieval times.

A leaf spring takes the form of a slender arc-shaped length of spring steel of rectangular cross-section. The center of the arc provides location for the axle, while tie holes are provided at either end for attaching to the vehicle body.

Fig: leaf spring

Typically when used in automobile suspension the leaf supports an axle and locates/ partially locates the axle. This can lead to handling issues (such as 'axle tramp'), as the flexible nature of the spring makes precise control of the unsprung mass of the axle difficult. Some suspension designs use a watts link (or a panhard rod) and radius arms to locate the axle and do not have this drawback. Such designs can use softer springs, resulting in better ride.

Objective

- The objective of the present work is to design, analyze and propose a method of fabrication of composite leaf spring for automobile suspension system. This is done to achieve the following
- This design helps in the replacement of conventional steel leaf springs with composite mono-leaf spring with better ride quality.

To achieve substantial weight reduction in the suspension system by replacing steel leaf spring with composite leaf spring.

Literature Review

G.h. goud and e. V.Goud[17] explained the modeling and design of leaf spring, used in automobile suspension systems. Static analysis determines the safe stress and corresponding pay load of the leaf spring and also to study the behavior of structures under practical conditions. The present work attempts to analyze the safe load of the leaf spring, which will indicate the speed at which a comfortable speed and safe drive is possible.

Weight Transfer In Leaf Spring Suspension System:

Weight transfer during cornering, acceleration or braking is usually calculated per individual wheel and compared with the static weights for the same wheels.

The total amount of weight transfer is only affected by four factors: the distance between wheel centers (wheelbase in the case of braking, or track width in the case of cornering) the height of the center of gravity, the mass of the vehicle, and the amount of acceleration experienced.

Jacking Forces

Jacking forces are the sum of the vertical force components experienced by the suspension links. The resultant force acts to lift the sprung mass if the roll center is above ground, or compress it if underground. Generally, the higher the roll center, the more jacking force is experienced.

Characteristics:

1. The leaf spring acts as a linkage for holding the axle in position and thus separate linkages are not necessary. It makes the construction of the suspension simple and strong.

2. Because the positioning of the axle is carried out by the leaf springs, it is disadvantageous to use soft springs i.e. springs with low spring constant.

Demerits of conventional leaf spring

- They have less specific modulus and strength.
- Increased weight.
- its corrosion resistance is less compared to composite materials.

Merits of composite leaf spring

- Reduced weight.
- Due to weight reduction, fuel consumption would be reduced.
- They have high damping capacity; hence produce less vibration and noise.
- they have good corrosion resistance.
- They have high specific modulus and strength.
- longer fatigue life.

Introduction To Composites

Composite materials are basically hybrid materials formed of multiple materials in order to utilize their individual structural advantages in a single structural material. The constituents are combined at a

macroscopic level and are not soluble in each other. The key is the macroscopic examination of a material wherein the components can be identified by the naked eye.

Advantages Of Composites:

The advantages of composites over the conventional materials are: High strength to weight ratio, high stiffness to weight ratio, high impact resistance, better fatigue resistance, Improved corrosion resistance, Good thermal conductivity, Low Coefficient of thermal expansion. As a result, composite structures may exhibit a better dimensional stability over a wide temperature range, high damping capacity.

Solid Works

Solid works is mechanical design automation software that takes advantage of the familiar Microsoft windows graphical user interface.

It is an easy-to-learn tool which makes it possible for mechanical designers to quickly sketch ideas, experiment with features and dimensions, and produce models and detailed drawings.

Modeling Of Leaf Spring

Specifications Of Design Data

Here Weight and initial measurements of Mahindra "Model - commander 650 di" light vehicle are taken.

Gross vehicle weight = 2150 kg

Un sprung weight = 240 kg

Total sprung weight = 1910 kg

Taking factor of safety (FS) = 1.4

Acceleration due to gravity (g) = 10 m/s²

There for; Total Weight (W) = 1910*10*1.4 = 26740 N

Since the vehicle is 4-wheeler, a single leaf spring corresponding to one of the wheels takes up one fourth of the total weight.

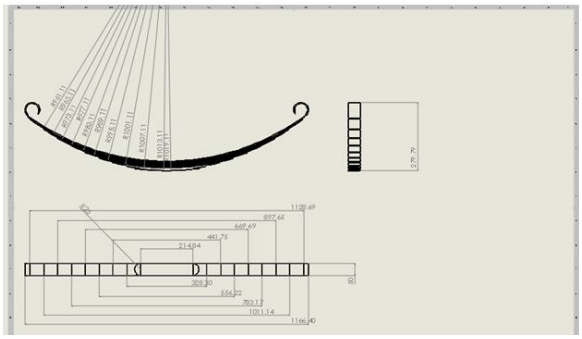
F = 26740/4 = 6685 N

Here we modeled leaf spring of three different thickness values they are 4mm, 5mm, 6mm.

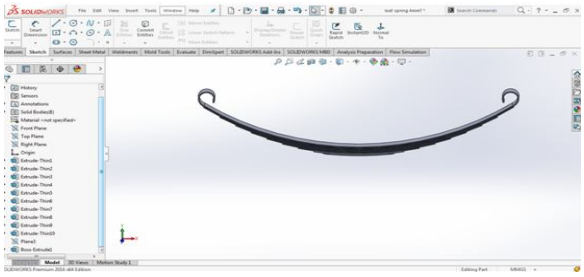
Design parameters of leaf spring:

Leaf no.	Full leaf length (mm) 2L	Half leaf length(mm) L	Radius of curvature R (mm)
1	1120	560	961.11
2	1120	560	967.11
3	1007	503.5	973.11
4	894	447	979.11
5	780	390	985.11
6	667	333.5	991.11
7	554	277	997.11
8	440	220	1003.11
9	327	163.5	1009.11
10	214	107	1015.11

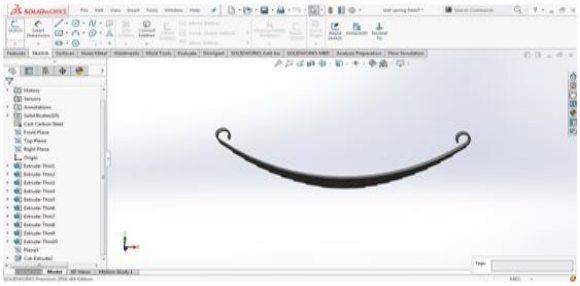
First 4mm thickness leaf spring is modeled as in following steps



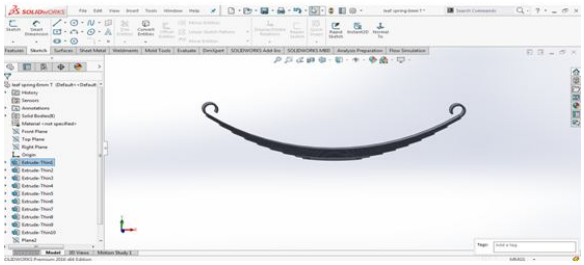
Leaf spring of 4mm thickness



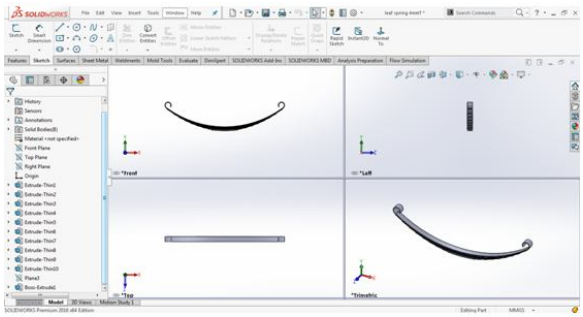
Leaf spring of 5mm thickness



Leaf spring of 6mm thickness



Four views of leaf spring



Finite Element Analysis

Finite element analysis (fea) is a computer-based numerical technique for calculating the strength and behavior of engineering structures. It can be used to calculate deflection, stress, vibration, buckling behavior and many other phenomena. It also can be used to analyze either small or large scale deflection under loading or applied displacement.

Introduction To Simulation

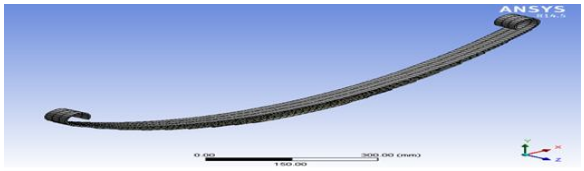
Simulation is a design analysis system. Simulation provides simulation solutions for linear and nonlinear static, frequency, buckling, thermal, fatigue, pressure vessel, drop test, linear and nonlinear dynamic, and optimization analyses.

Static Analysis

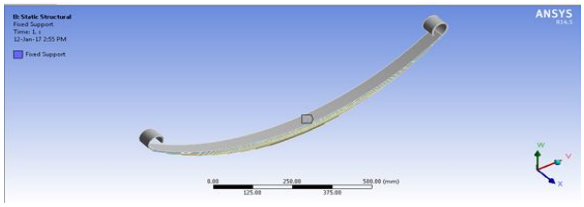
Static analysis deals with the conditions of equilibrium of the bodies acted upon by forces. A static analysis can be either linear or non-linear. All types of non-linearities are allowed such as large deformations, plasticity, creep, stress stiffening, contact elements etc. This chapter focuses on static analysis. A static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those carried by time varying loads.

4mm Thickness

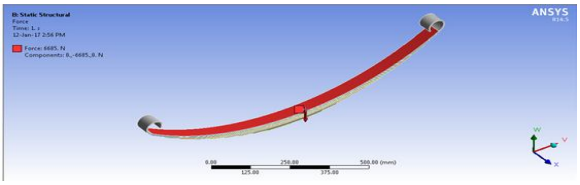
Mesh



Load Force: 6685N



Fixed

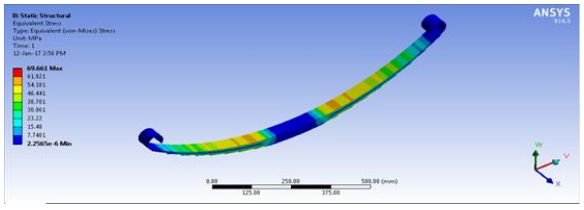


Material properties

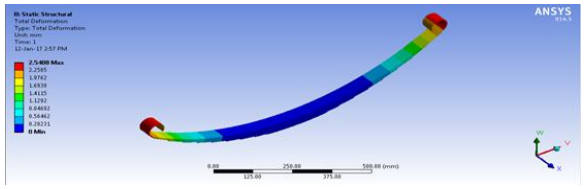
Material	Density(kg/m^3)	Young's modulus(MPa)	Poison's ratio	Tensile yield strength(MPa)
Carbon epoxy	1600	1.4e005	0.3	1900
Carbon steel	7840	2.1e005	0.33	8.e-004
e-glass epoxy	2600	0.8e005	0.23	2050

Carbon Steel

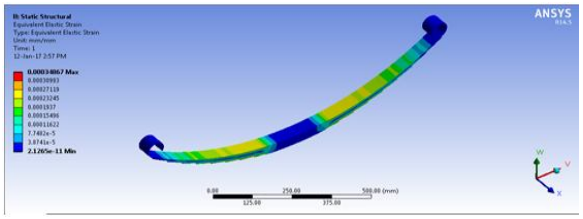
Maximum Stress



Total Deformation

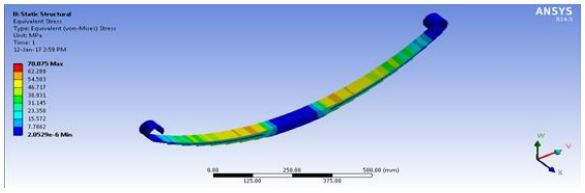


Maximum Strain

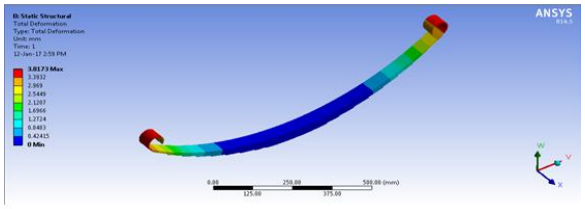


Carbon epoxy

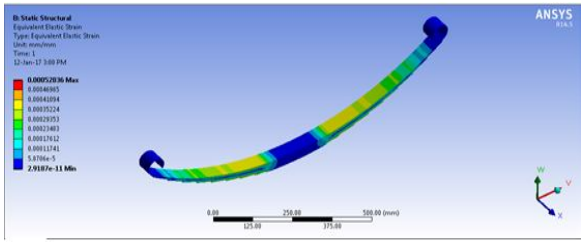
Max stress



Total deformation

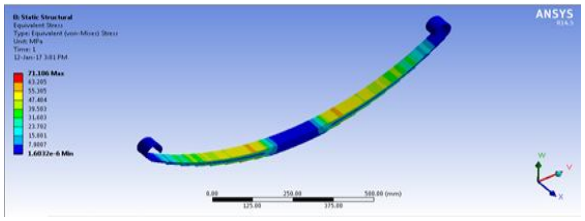


Maximum strain

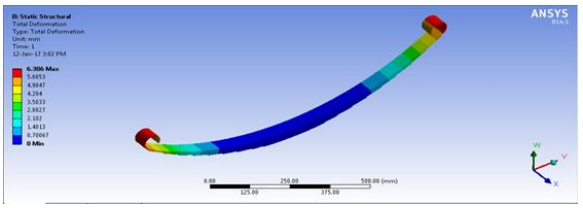


e-glass epoxy

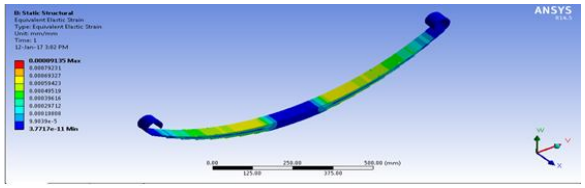
Maximum stress



Total deformation



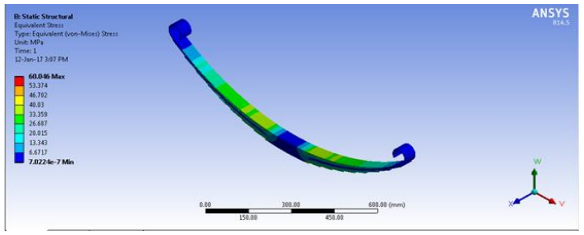
Maximum strain



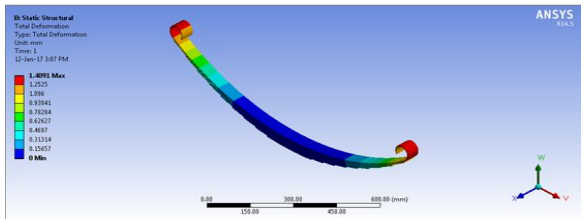
5mm thickness leaf spring

carbon steel

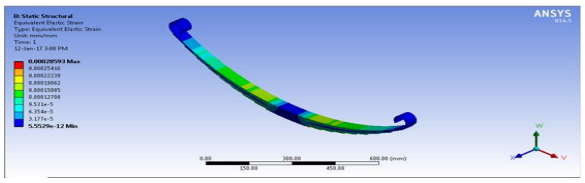
Maximum stress



Total deformation

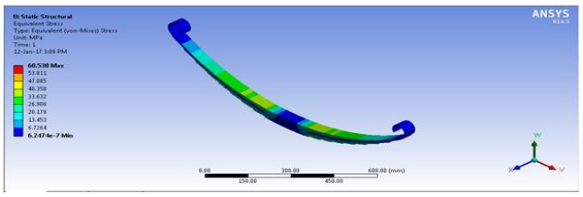


Maximum strain

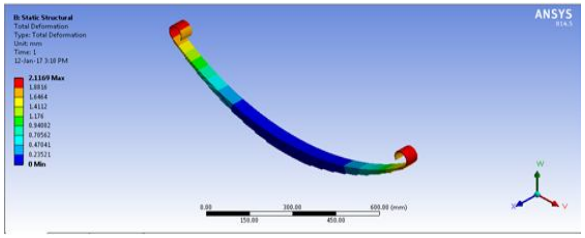


Carbon epoxy

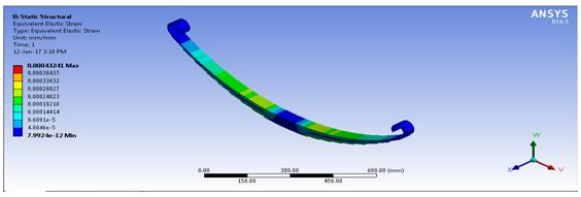
Max stress



Total deformation

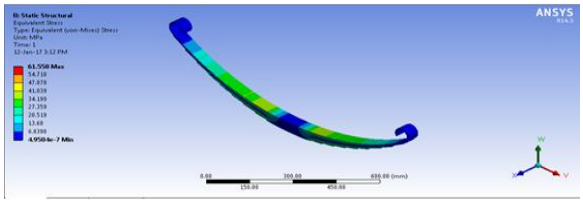


Maximum strain

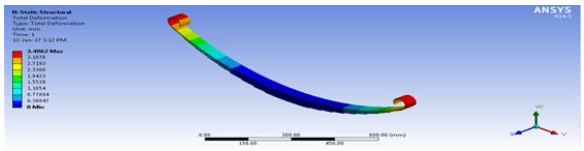


E-glass epoxy

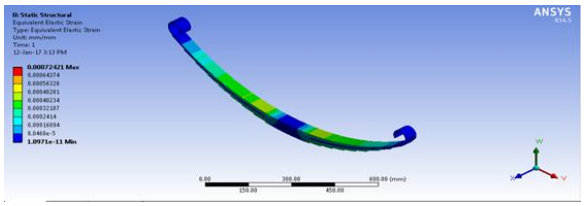
Maximum stress



Total deformation



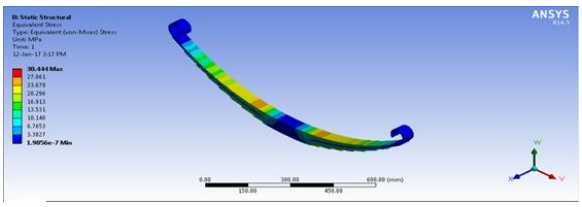
Maximum strain



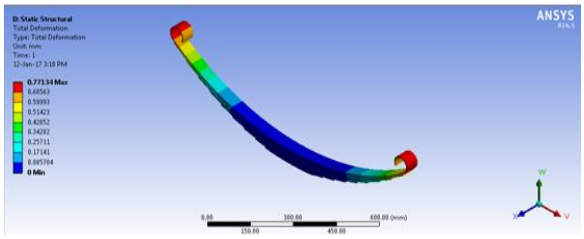
6mm thickness leaf spring

Carbon steel

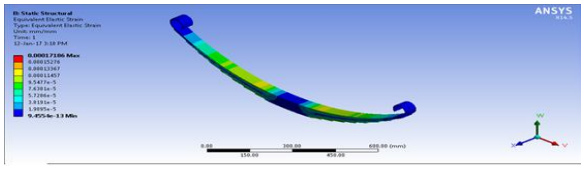
Maximum stress



Total deformation

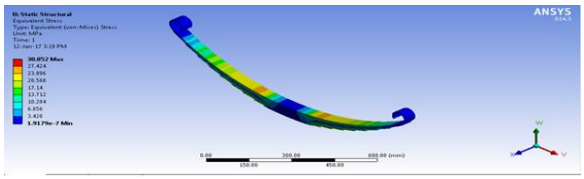


Maximum strain

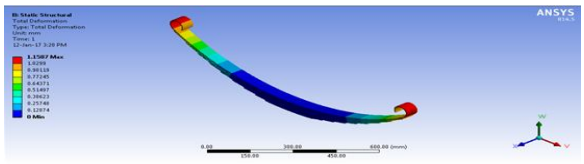


Carbon epoxy

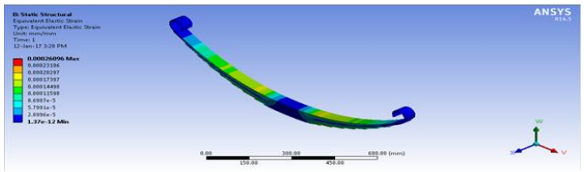
Max stress



Total deformation

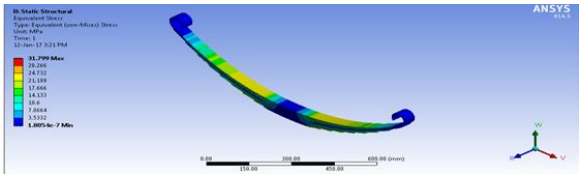


Maximum strain

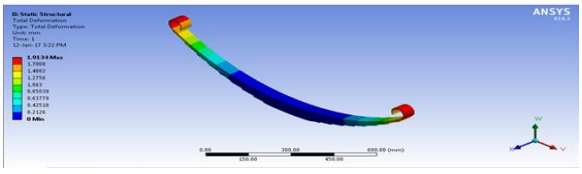


E-glass epoxy

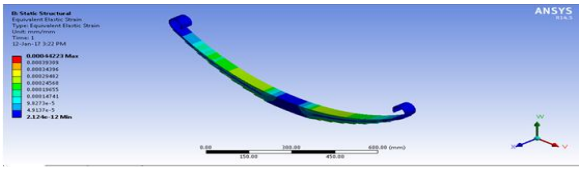
Maximum stress



Total deformation



Maximum strain



For 4mm thickness

Material	Max stress	Total deformation	Max strain
Carbon steel	69.661	2.5408	0.00034867
Carbon epoxy	70.075	3.8173	0.00052836
E-glass epoxy	71.106	6.306	0.00089135

For 5mm thickness

Material	Max stress	Total deformation	Max strain
Carbon steel	60.046	1.4091	0.00028593
Carbon epoxy	60.538	2.1169	0.00043243
E-glass epoxy	61.538	3.4962	0.00072421

For 6mm thickness

Material	Max stress	Total deformation	Max strain
Carbon steel	30.444	0.77134	0.00017186
Carbon epoxy	30.852	1.1587	0.00026096
E-glass epoxy	31.799	1.9134	0.00044223

Conclusion:

- Design and analysis of leaf spring is done
- Modeling of leaf spring is done in solidworks 2016 design software
- First 4mm thickness leaf spring then 5 and 6 mm thickness are modeled
- The models are saved as igs files to import in ansys
- Structural analysis is carried out in ansys by applying three different materials such as carbon epoxy, carbon steel and e-glass epoxy at load 6685n force is applied on leaf spring for three different thickness leaf springs
- The material properties of the above materials are studied
- From the results we can conclude that already 6mm thickness is existing by we reduced it to 5mm and 4mm by varying the thickness reduction in weight occurred from the analysis carbon steel material for 5mm thicknesss is showing less stress compared to 4mm thickness leaf spring
- Leaf spring containing 4mm thickness undergone maximum stress though the weight reduction is maximum but stability to oppose the load is low but 5mm thickness leaf spring got the values nearer to 6mm and it has low weight compared to 6mm leaf spring
- Hence we can conclude that the leaf spring containing 5mm thickness applied with carbon steel material is showing best results

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