DESIGN AND ANALYSIS OF LEAF SPRING
1 Mr. RAJA MANAS MACHERLA, 2 Mr. SRIKANTH BAJAJ
1 Bachelor of technology, Department of MECH, Mahatma Gandhi Institute of Technology, Gandipet Main Road, Kokapet, Hyderabad, Telangana, INDIA
2 Bachelor of technology, Department of MECH, Mahatma Gandhi Institute of Technology, Gandipet Main Road, Kokapet, Hyderabad, Telangana, INDIA

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 two different thickness 5mm and 6mm and analysis is done using ansys 14.5 workbench with three different materials such as High carbon steel, S2 glass, 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:

<table>
<thead>
<tr>
<th>Leaf no.</th>
<th>Half leaf length (mm)</th>
<th>Half leaf length (L)</th>
<th>Ratio of curvature R (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>117.4</td>
<td>58.0</td>
<td>961.11</td>
</tr>
<tr>
<td>2</td>
<td>117.4</td>
<td>58.0</td>
<td>961.11</td>
</tr>
<tr>
<td>3</td>
<td>117.4</td>
<td>58.0</td>
<td>961.11</td>
</tr>
<tr>
<td>4</td>
<td>117.4</td>
<td>58.0</td>
<td>961.11</td>
</tr>
<tr>
<td>5</td>
<td>117.4</td>
<td>58.0</td>
<td>961.11</td>
</tr>
<tr>
<td>6</td>
<td>117.4</td>
<td>58.0</td>
<td>961.11</td>
</tr>
<tr>
<td>7</td>
<td>117.4</td>
<td>58.0</td>
<td>961.11</td>
</tr>
<tr>
<td>8</td>
<td>117.4</td>
<td>58.0</td>
<td>961.11</td>
</tr>
<tr>
<td>9</td>
<td>117.4</td>
<td>58.0</td>
<td>961.11</td>
</tr>
<tr>
<td>10</td>
<td>117.4</td>
<td>58.0</td>
<td>961.11</td>
</tr>
</tbody>
</table>

First 5mm thickness leaf spring is modeled as in following steps

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.
Fixed

High Carbon Steel
Maximum Stress

Total Deformation

Maximum Strain

S2 Glass
Max stress

Total deformation

Maximum strain

E-glass epoxy
Maximum stress
Total deformation

Maximum strain

6mm thickness leaf spring
High carbon steel
Maximum stress

Total deformation

Maximum strain

S2 Glass
Max stress

Total deformation

Maximum strain
E-glass epoxy

Maximum stress

Total deformation

Maximum strain

Results

5mm thickness

<table>
<thead>
<tr>
<th>Material</th>
<th>Max stress (MPa)</th>
<th>Total deformation (mm)</th>
<th>Max strain</th>
</tr>
</thead>
<tbody>
<tr>
<td>High carbon steel</td>
<td>16.889</td>
<td>0.41785</td>
<td>0.0017949</td>
</tr>
<tr>
<td>S2 glass</td>
<td>16.928</td>
<td>0.048101</td>
<td>0.0002689</td>
</tr>
<tr>
<td>E-glass epoxy</td>
<td>19.928</td>
<td>0.040178</td>
<td>0.00021152</td>
</tr>
</tbody>
</table>

6mm thickness

<table>
<thead>
<tr>
<th>Material</th>
<th>Max stress (MPa)</th>
<th>Total deformation (mm)</th>
<th>Max strain</th>
</tr>
</thead>
<tbody>
<tr>
<td>High carbon steel</td>
<td>16.889</td>
<td>0.41785</td>
<td>0.0017949</td>
</tr>
<tr>
<td>S2 glass</td>
<td>16.928</td>
<td>0.048101</td>
<td>0.0002689</td>
</tr>
<tr>
<td>E-glass epoxy</td>
<td>19.928</td>
<td>0.040178</td>
<td>0.00021152</td>
</tr>
</tbody>
</table>

Conclusion:

- Brief study about leaf spring uses working and types are discussed in this project.
- Modeling of leaf spring is done in solid works 2016 design software.
- First 5mm thickness leaf spring and then 6mm 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 one general material High carbon steel and two glass fibre material S2-Glass and E-Glass epoxy.
- Load 6685n force is applied on leaf spring for two different thickness 5mm and 6mm leaf springs.
- The material properties of the above materials are studied.
- 6mm thickness of leaf spring is already exist in market hence we decrease the thickness of leaf spring from 6mm to 5mm and study result to get best least weight ratio strength by decreasing its thickness.
- Results after applying load on each material is noted and tabulated.
- From result table we conclude that high carbon steel showing the least stress value and S2 glass fibre material showing least deformation values.
• As the high carbon steel having more weight as compare to glass fibre materials, and glass fibre material showing nearly same stress value with least weight ratio so we can conclude that S2 glass fibre glass material could be best preference material for leaf spring.
• Hence Design and analysis of leaf spring is done.

References
[2]. R.s.khurmi and j.k.gupta machine design chapter 23.
[4]. Rajendran i., vijayarangan s., “design and analysis of a composite leaf spring”journal of institute of engineers, india ,vol.-8.2-2002
[6]. Mr. V. Lakshmi narayana, “design and analysis of mono composite leaf spring for suspension in automobiles” ijert 2278-0181, vol. 1 Issue 6, august – 2012
[7]. Shishay amare gebremeskel, “design, simulation, and prototyping of single composite leaf spring for light weight vehicle”, global Journals inc. (usa) 2249-4596, volume 12 issue 7, 21-30, 2012
[10]. Mr. V. K. Aher *, mr. P. M. Sonawane , static and fatigue analysis of multi leaf spring used in the suspension system of lcv, (ijera)