DESIGN AND ANALYSIS OF LEAF SPRING USING ANSYS

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Abstract
Computer aided designing (CAD) is being widely used in different industries for product testing and manufacturing, this paper consist of design and analysis of leaf spring using ANSYS 19.2. Static structural tool has been used of ANSYS. Leaf springs are used in heavy load vehicle where load is much larger than in passenger vehicles, they are used in vehicles which are limited to varying cycles stress to millions thus eventually leads to failure of fatigue. High elastic material springs are used which possess maximum strength and fatigue effects. Weight reduction is one of the major concern while designing a vehicle as it helps in design optimization and fuel economy. A three layer composite leaf spring with full length leave. E-glass/Epoxy composite material has been used and is compared with conventional steel leaf spring. After conducting various tests it is found that e-glass/epoxy material is better in strength and lighter in weight as contrast with conventional steel leaf spring.

Keywords: CAD, ANSYS 19.2, leaf spring, composite material

Introduction
Leaf springs are suspension system used in vehicles. They were originally called carriage or laminated springs. It is made of a arc shape slender piece of steel that are stacked with the same material in smaller sizes and bolted together creating a reinforced bow like item. A leaf spring works on the principle of bending. When load is applied at the ends bending occurs. Naturally the structure opposes bending. This results in a reaction force which opposes the load applied. Thereby we get the spring property of the leaf spring.

The overall purpose of leaf spring is to provide support to a vehicle and to provide a smoother ride absorbing any bumps or shocks from potholes on the road are track. Leaf springs are also used to locate the axle and control the height at which the vehicle rides and helps keep the tyres aligned on the road. Leaf springs are a basic form of suspension made up of layers of steel of varying sizes sandwiched one upon the other. Most leaf spring setups are formed into an elliptical shape through the use of spring steel which has properties that allow it to flex as pressure is added at either end, but then returning to its
original position through adamping process. The steel is generally cut into rectangular sections and then once held together by metal clips at either end and a large bolt through the centre of the leafs. It is then mounted to the axle of the vehicle using large Ubolts.

![Figure 1: schematic of leaf spring](image1)

**Advantages**
The advantages of leaf spring are that due to sheer amount of metal layered together, leaf springs offer a large amount of support between the wheel, axles and the vehicle's chassis. They can take huge vertical loads being applied to them due to their tight knit structure, hence why heavy duty industries still use them. Vertical loading is also distributed throughout the length of the leaf spring rather than acutely through a small spring and damper.

**Disadvantages**
Few disadvantages of leaf springs are that they allow very few directions of motions and are only designed to move vertically, while a spring and damper combination can be manipulated into a much larger range of motion. Leaf springs are firmly clamped together and bolted to the chassis as well as clip to the axle, thus giving little scope for any other direction of motion. Suspension in place.

**Literature review**
Pozhilarasu V. and T ParameshrwanPillai [3] studied analysis of steel and composite leaf spring. They used ANSYS software to compare conventional steel and composite (Glass fibre reinforced plastic – GFRP ) leaf spring. They test both materials for same parameters. They fabricated a glass/epoxy composite leaf spring and universal testing machine was used to test the results for both the spring.

Dev Dutt Dwivedi and V. K. Jain [2] analyzed and design composite leaf spring, they used Static structural tool of ANSYS to test various load condition. A three layer composite leaf spring (E-Glass/epoxy) was used. On testing they found that E-Glass/epoxy material is better in strength and lighter than conventional steel leaf spring.

Dara Ashok, M.V. Mallikarjun and Venkata Ramesh Mamilla [4] gave design and analysis of automobile multi leaf spring using composite material. In addition to shock absorbing multi leaf spring carries s lateral loads, brake torque, driving torque. Leaf spring are being used from very long time in vehicles especially in commercial vehicles. Due to high strength to weight ratio it is being used by various industries. Springs has ability to store and absorb more amount of strain energy and ensuring comfortable suspension system. Author give FE model of the leaf spring, which is generated in Pro-E 4.0 and imported in ANSYS-11 for finite element analysis. The FE analysis of the leaf spring has been performed by discretization of the model in infinite nodes and elements and refining them under defined boundary condition. A comparison of both i.e. theoretical analysis and FEA results have been done to conclude. Result is, the finite element analysis of multi leaf spring is performed using ANSYS-11 workbench.

**Composite material**
A composite material is made out of two or more constituents joined on a naturally visible scale by mechanical and chemical bonds. Composites are mixture of two materials in which one of the material is known as the "matrix phase" and is implanted in the other material called the "reinforcing stage". Numerous composite materials offer modulus that is either equivalent or superior to any metals. In light of their low specific gravities, the strength to weight-proportion and modulus to weight-proportions of these composite materials are better than those of metallic materials. The fatigue quality weight proportions and fatigue. Damage tolerance of numerous composite overlays are fantastic. Thus, fibre composite have risen as a note worthy class of basic material, are either utilized or being considered as substitutions for metal in numerous weight basic parts in aviation, car and different businesses. High internal damping limit is another advantage. This prompts better vibration energy and results in decreased noise to neighbouring structures. High damping limit of composite materials can be advantageous in numerous car applications in which noise, vibration, and hardness is a basic issue for traveller’s comfort.

**Design in ANSYS**
The design of the leaf spring on ANSYS is shown in figure no. 3 and the dimensions are given in the table 1.

![Figure 2: Design of leaf spring in ANSYS](image2)
Table 1: Details of leaf spring

<table>
<thead>
<tr>
<th>Leaf spring part</th>
<th>radius</th>
<th>Vertical distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye outer part</td>
<td>3.5mm</td>
<td></td>
</tr>
<tr>
<td>Eye inner part</td>
<td>1.7mm</td>
<td></td>
</tr>
<tr>
<td>Master leaf</td>
<td>90mm</td>
<td>2mm</td>
</tr>
<tr>
<td>Graduated leaf 1</td>
<td>92mm</td>
<td>2mm</td>
</tr>
<tr>
<td>Graduated leaf 2</td>
<td>94mm</td>
<td>2mm</td>
</tr>
<tr>
<td>Bottom leaf</td>
<td>98mm</td>
<td>2mm</td>
</tr>
<tr>
<td>Load leaf</td>
<td>40N</td>
<td></td>
</tr>
<tr>
<td>Span (eye center to center)</td>
<td>84mm</td>
<td></td>
</tr>
<tr>
<td>No. of Graduated leaf</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Width of Leafs</td>
<td>7mm</td>
<td></td>
</tr>
</tbody>
</table>

Meshing of leaf spring

Figure 3: Meshing of leaf spring in ANSYS

Results
From the analysis of structural steel leaf spring and E-composite E-glass/epoxy leaf spring is less compared to glass/epoxy, it observed that the total deformation of for structural steel leaf spring. Maximum shear stress and E-glass/epoxy material is less compared to conventional maximum principal stress is less in composite E-glass/epoxy steel leaf spring material. Equivalent stress generated in the as compared to conventional structural steel material.

Figure 5: Total deformation in E-glass/epoxy
Figure 6: Equivalent stress in steel
Figure 7: Equivalent stress in E-glass/epoxy
Figure 8: Directional deformation in steel leaf spring
Figure 9: Directional deformation in E-glass/epoxy
Table 2: Comparison of steel and E-glass/epoxy

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Conventional steel leaf</th>
<th>E-GLASS/EPOXY COMPOSITE LEAF SPRING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Deformation (maximum)</td>
<td>1.1353e-9</td>
<td>6.5303e-7</td>
</tr>
<tr>
<td>Equivalent stress (maximum)</td>
<td>5.6913</td>
<td>4.5706e-5</td>
</tr>
<tr>
<td>Directional deformation (maximum)</td>
<td>1.253e-10</td>
<td>1.4879e-8</td>
</tr>
<tr>
<td>Maximum shear stress (maximum)</td>
<td>2.9168</td>
<td>2.3549e5</td>
</tr>
<tr>
<td>Maximum principal stress (maximum)</td>
<td>0.68649</td>
<td>1.5615e5</td>
</tr>
</tbody>
</table>

Conclusion
Analysis of leaf spring with different material shows that composite E-glass/epoxy shows less stress for a particular load as compared to conventional steel material. Since weight factor is one of the major concern while designing vehicles and weight of composite material e-glass/epoxy is less than steel hence it shows better results when compared with steel.

References
[2] Dev Duttdwivedi, V.K. Jain, ’’design and analysis of automobile leaf spring using ansys’’, international journal of current engineering and scientific research (ijcesr), volume-3, issue-1,