Modeling and Finite Element Analysis of Leaf Spring

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ABSTRACT
Leaf springs are one of the oldest suspension components they are still frequently used, especially in commercial vehicles. Weight reduction is now the main issue in automobile industries. In the present work, existing mono steel leaf spring of a Tata Bus is taken for modelling and analysis. Finite element method has been implemented to modify the existing leaf spring with considering the dynamic loading.

This work involves design and analysis of a conventional leaf spring under static and dynamic loading conditions. The 3D model is prepared in Creo 1.0, and then analysis is performed in the ANSYS 11.0 by considering same load in static and dynamic loading. For the cost reduction in existing leaf spring modification carried out by iteration method considering three cases such as varying number of leaves, varying width and varying thickness. The optimisation has been carried out to satisfy the permissible value of factor of safety. The results are verified by comparison of Analytical and Finite Element Method. All analytically calculated values of deflection and stresses are closely matching with values obtained from ANSYS software.

Keywords
Leaf spring, failure analysis, spring steel, finite element method.

1. INTRODUCTION
Leaf springs are widely used in automobile and in railway. The leaf spring should absorb the vertical vibrations and impacts due to road irregularities by means of variations in the spring deflection so that the potential energy is stored in spring as strain energy and then released slowly so increasing the energy storage capabilities of a leaf spring and ensures a more compliant suspension system .Leaf springs are probably one of the oldest forms of spring-type suspension systems, having been in use since Medieval times. Until recently, leaf springs were a common rear suspension component of most automobiles. The introduction of light-weight front-wheel drive vehicles has basically made the use of leaf springs unnecessary, and automobile manufacturers are now using coil springs for both front and rear suspension systems. Leaf springs are now generally used only for heavier commercial-type vehicles such as trucks, vans, trailers, and railroad cars.

There are two basic types of leaf springs:

- Mono-leaf
- Multi-leaf.

1.1 Mono-Leaf Spring
A mono-leaf spring has only one arc-shaped steel strip, which is usually very thick in the middle with much thinner ends.

1.2 Multi-Leaf Spring
Multi-leaf spring is constructed of several arc-shaped steel strips of varying lengths that are stacked together with the longest strip at the top, and the shortest strip at the bottom.

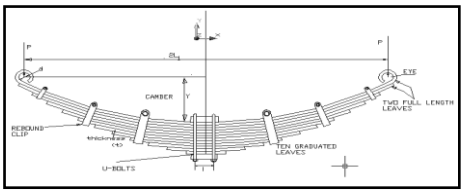

Fig.1. Multi leaf spring

2. LITERATURE REVIEW
Yohannes Regassa, R. Srinivasa Moorthy & Ratnam Uppala [2013] , Studied and analyze how failure occurs on the semi-elliptical master leaf spring of a car by analytical approach and using FEM simulation. To overcome this failure, multiple trials have been made in terms of change of material and thickness of the semi-elliptical leaf spring and they found out that carbon steel improves the resistance to permanent set of springs.[1]

Meghavath. Peerunaik, Tippa Bhimasankara Rao ,K.N.D. Malleswara Rao [2013], represent to estimate the deflection, stress and mode frequency induced in the leaf spring of an army jeep.They conclude that static analysis results of mono composite Carbon Epoxy leaf springs are compared to steel leaf spring. The results show that [1] the stresses in the composite leaf spring are much lower than that of the steel spring. [2] The composite spring can designed to strengths and stiffness much closer to steel leaf spring by varying the layer.[3] configuration and fiber orientation angles. Vivek Rai , Gaurav Saxena [2013] , [3] described to replace the multi-leaf steel spring by mono composite leaf spring for the same load carrying capacity and stiffness. These work involves the comparison of steel leaf material EN 47 and Composite material leaf spring under static loading conditions the model is preferred of in Pro-E 4.0 and then analysis is perform through ANSYS 12.1 from the result obtained they concluded that the development of a composite mono leaf spring has very effective than steel leaf spring. [2]

Mr. V. K. Aher, Mr. P. M. Sonawane [2012], presented to predict the fatigue life of semi-elliptical steel leaf spring of Light Commercial Vehicle, along with analytical stress and deflection calculations. And aim of this paper is to increase load carrying capacity & life cycle by modifying existing multi leaf spring of vehicle. They found out it give information for the manufacturer to improve the fatigue life of the spring using CAE tools. It can help to reduce cost and times in research and development of new product [4]

B.Vijaya Lakshmi I Satyanarayana, [2011], this paper represent to compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. The dimensions of an existing conventional steel leaf spring of a Heavy commercial vehicle taken Same dimensions of conventional leaf spring was used to fabricate a composite multi leaf spring using E-GLASS/EPOXY, C-GLASS/EPOXY, S- GLASS/EPOXY unidirectional laminates. Pro/Engineer software was used for modeling and COSMOS was used for analysis. Static & Dynamic analysis of Leaf spring is performed using COSMOS. So they found that S-glass epoxy is the best material to manufacture leaf spring because of good structural stability low production cost and good efficiency. [5]

D. Helmen Devaraj, M. Venkatesan [2012], this paper represents design and experimental analysis of composite leaf spring made of glass fiber reinforced polymer. The objective was to compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. The design constraints were stresses and deflections. The dimensions of an existing conventional steel leaf spring of a light commercial vehicle are taken. Same dimensions of conventional leaf spring were used to fabricate a composite multi leaf spring using E- Glass/Epoxy unidirectional laminates. Static analysis of 2-D model of conventional leaf spring is also performed using ANSYS 10 and compared with experimental results. The 3-D modeling of composite leaf spring is done and analyzed using ANSYS. From the results, they observed that the composite leaf spring is lighter and more economical than the conventional steel spring with similar design specifications. [6]

Pankaj Saini, Ashish Goel, Dushyant Kumar [2013], compared the stresses and weight saving of composite leaf spring with that of steel leaf spring. A single composite leaf spring was designed and it is shown that the resulting design and simulation stresses was much below the strength properties of the material satisfying the maximum stress failure criterion. From the static analysis results, we see that the. Among the three composite leaf springs, only graphite/epoxy composite leaf spring has higher stresses than the steel leaf spring. The leaf spring was modeled in Auto-CAD 2012 and the analysis was done using ANSYS software. A comparative study has been made between steel and composite leaf spring with respect to strength and weight.[7]

From the literature review some authors considered three composite materials for analysis of mono composite leaf spring. They are Eglass/epoxy, Graphite epoxy, and carbon epoxy but they have not considered the variations in number of leaves and dimensions of leaf spring. D. Helmen Devaraj ,M. Venkatesan has worked on the development of composite leaf spring having constant cross sectional area and comparative study has been made between steel and composite. But they have not considered change in material, and variation in number of leaves.

3. MATERIALS USED IN LEAF SPRING

The various considerations for the design of semielliptical leaf spring of the bus have been presented below.

The different materials are used for the design of leaf spring. The details of which are presented below. Materials for leaf spring are Plain carbon steel, Chromium vanadium steel, Chromium-Nickel- Molybdenum steel, Silicon-manganese steel, are the typical materials that are used in the design of leaf springs.

3.1 Material Properties of Steel 55Si2Mn90

Parameters of steel leaf spring: Material selected – Steel 55Si2Mn90

Table 3.1: Material properties of Steel 55Si2Mn90

Parameter	Value
Yield strength (N/mm2)	1470
Young's modulus	2.1× 105 N/mm^2
Design stress	388.2 N/mm^2
Normal static loading	3850 N
Spring weight	280 kg

4. COMPARISON BETWEEN MATERIAL REQUIREMENTS IN LEAF SPRINGS

1. Composite material.
2. E-glass/epoxy or Rain forced polymer.
3. EN-45 Steel

4.1Composite Material

A composite material is defined as a material composed of two or more constituents combined on a macroscopic scale by mechanical and chemical bonds. Many composite materials offer a combination of strength and modulus that are better than any traditional metallic materials. The fatigue strength weight ratios as well as fatigue damage tolerances of many composite materials excellent.

For these reasons, fibre composite have emerged as a major class of structural material and are considered as substitutions for metal in many weight-critical components in aerospace, automotive and other industries. High damping capacity, This leads to better vibration energy absorption within the material and results in reduced transmission of noise and vibration to neighbouring structures.

4.2. Glass Fiber

Glass fiber is commonly used as an insulating material. It is also used as a reinforcing agent for many polymer products; to form a very strong and light fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), popularly known as "fiberglass". Glass fiber has roughly comparable properties to other fibers such as polymers and carbon fiber. Although not as strong or as rigid as carbon fiber.It is much cheaper and significantly less brittle.

4.3 Steel Spring

EN45 is commonly used in the automotive industries for the manufacture and repair of leaf springs. Applications EN45 is used widely in the motor vehicle industry and many general engineering applications. Typical applications include leaf springs, truncated conical springs, helical springs and spring plates.

5. COMPARISION BETWEEN SHAPES OF LEAF SPRINGS

1. Conventional and Parabolic leaf spring
2. Elliptical leaf spring

5.1 Parabolic and Conventional Spring

A parabolic spring is basically a leaf or a set of leaves which are tapered in a parabolic way rather than a linear. So from the middle, where leaf is thick, to the ends, where it is thinner, the tapering steps down in a parabolic manner. The tapering in a single leaf handles the force distribution from the vehicle to the axle and works better than conventional spring. Parabolic spring assembly contains less number of leaves as compared to Conventional spring assembly but can carry equal load.

5.2 Elliptical Leaf Spring

Leaf springs are commonly called elliptical or semi-elliptical, as they are shaped like a section from an ellipse. Multiple trials have been made in terms of change of material and thickness of the semi-elliptical master leaf.

6. CONCLUSION

This research is started with the objective is to study the reasons of failure of leaf spring belt and to design t he Spring with maximum weight that is capable of carrying static external forces without failure. From the preliminary study it is concluded that from the comparison of materialsEglass/epoxy material is better than composite material & EN-45 Steel. And in comparison of shapes parabolic spring is better than conventional & elliptical leaf spring. The project is in progress. Further it is decided to develop the CAD model of Leaf Spring. and to crray out Modeling by using Pro-E & analysis is carried out by using ANSYS Software by applying boundary conditions, & considering Stresses acting on leaf Spring & meshing on each component.

7. REFERENCES

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