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Design and Analysis of Leaf Springs with Structural Steel and Chromium Vanadium Steel

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***Abstract:** Leaf springs are part of the suspension system on most vehicles and add weight to vehicles due to the traditional steel material. The automotive industry is interested in replacing traditional materials such as steel with other materials for various reasons, such as different mechanical properties. Intensive research is being carried out into replacing the leaf spring with a composite material. The composite material meets various test requirements of automotive standard due to its good elastic properties, high strength-to-weight ratio and lighter weight than steel. The purpose of the article is to focus on various topics such as weight, stresses during construction, modelling and experimental testing of composite leaf springs. In this work, the stress and deflection analysis of the leaf spring is calculated using the finite element method. Leaf springs are analyzed for stress and deflection in ANSYS 14.5. The results show, based on various calculations and observed data that with similar load capacities, induced stresses and deformations are minimized by replacing the steel leaf springs with fibre composite leaves. The analysis was performed considering the leaf spring engine model with the same dimension geometry to reduce the leaf spring weight. A composite material is chosen for the leaf spring. The analysis was performed on the ANSYS 14.5 spring with the same load condition as the steel and composite leaf springs in terms of strength and weight. From the static analysis and test results, after the design change and stress analysis, the composite leaf springs were minimized by about 71.73% and the stress was reduced by 50-80%.*

***Index Terms:** Leaf springs, Stress, Deflection ANSYS 14.5, Structural Steel and Chromium Vanadium Steel*

I. INTRODUCTION

To get an idea of how a leaf spring works, think of a pool trampoline. A trampoline is a support with a load, a plunger, at the free end. The diver begins to rock the board back and forth at the free end, using the board's spring action to jump. A trampoline is basically a leaf spring. leaf springs are widely used in suspension systems for railroad cars and wagons. For a cantilever type leaf spring where the leaf thickness h is the same, consider a leaf with the same width b and a leaf whose width decreases uniformly from b. The peak stress σmax and the peak deflection δmax can be derived from the basic equations of bending and bending stress. In the second case, note that if a door of different width (triangular as shown in the figure) is used instead of a door of the same width, the bending stress in each section will be the same and equal to σmax. This is called a uniform resistive layer. Also, the peak deflection is larger and has more compliance compared to its uniform width counterpart. Elasticity is known to be the ability to absorb potential energy when deformed. However, it should be noted that the drill must have a certain width to withstand the cutting force. This is represented by the red area in the figure. First, an uneven width door is a better design than an even width door.

II. LITERATURE REVIEW

Reducing weight while increasing or maintaining the strength of products is becoming a very important research topic in our m odern world. Composites are one of the families of materials that are attracting researchers and offering solutions to this problem. In this article we describe the design and analysis of composite leaf springs. The aim is to compare the loads and weight savings of composite leaf springs with those of steel leaf springs. The design constraint is rigidity. The automotive industry has a keen inter est in replacing steel springs with composite leaf springs because of the high strength-to-weight ratio of composite materials and go od corrosion resistance. Glass fiber reinforced polymer (E-glass/epoxy resin), carbon epoxy resin and graphite epoxy res in were selected as the material compared to conventional steel. Design parameters were selected and analyzed with the aim of minimizing the weight of the composite leaf spring compared to the steel leaf spring. The leaf spring was modeled in Auto-CAD 2012 and the analysis was performed with ANSYS 9.0 software[1].

This article will review some general studies on the design, analysis, and manufacture of compound crossbows. Leaf springs are among the oldest suspension components and are still frequently used, especially in commercial vehicles.

The literature indicates that there is growing interest in replacing steel springs with composite leaf springs. A vehicle's suspension system has a significant impact on the behavior of the vehicle, e.g. H.Vibration properties including ride comfort, stability[2]. Leaf springs are widely used in vehicle suspension systems and are subjected to millions of different loading cycles leading to fatigue failure. Much research has been done to improve crossbow performance. Many materials are used for the crossbow.

However, fiberglass material has been found to have better strength properties and lighter weight compared to leaf spring steel. In this article, the author reviews some articles on the use of alternative materials and the material's impact o n crossbow performance [3].

The purpose of this review article is to present a general study of leaf spring design and analysis. A vehicle's suspension system has a significant impact on the behavior of the vehicle, e.g. H. vibration characteristics, including ride comfort, stability, etc. Leaf springs are widely used in vehicle suspension systems and are subjected to millions of different loading cycles leading to fatigue failure. Much research has been done to improve the performance of the crossbow. Now the automotive industry has shown interest in replacing steel springs with composite leaf springs. In general, fiberglass material has better strength properties and is lighter compared to leaf spring steel. This article discusses some articles on leaf spring design and performance analysis and leaf spring fatigue life prediction. There is also the analysis of error in the crossbow [4]. The analysis of the crossbow with Ansys is also carried out. Automakers can reduce the cost and time involved in product development while improving the safety, comfort and durability of the vehicles they manufacture. The predictive power of CAE tools has advanced to the point where much design verification is now done through computer simulation rather than physical prototype testing [5].

In this work, work is performed on an eight-leaf multi-leaf spring used in a commercial vehicle. In order to reduce the cost and weight of the leaf spring, the automotive sector is replacing steel leaf springs with leaf springs made of fiber composite materi als. The aim of the study was to replace steel material with leaf springs.

Fiber-reinforced plastic glass was chosen as the material. A spring of constant width and thickness with different configurations of composite leaves was used for the analysis. In this study, all models are designed with a safety factor of 2.5 and the analysis is done with ANSYS software. deflection and stress results were reviewed for the analysis results[6].The result shows that the composite spring has significantly lower stresses than the steel leaf spring and the weight of the composite spring was reduced. By capturing the fundamentals of the combination of different materials and hence their equivalent modulus, the overall stiffness properties of the multi-layer construction are influenced. Keywords: leaf springs, finite element analysis and composite s, composite leaf springs[7].

This article discusses composite structures for conventional metal structures, which have many advantages due to the higher specific stiffness and strength of composite materials. The automotive industry has shown increased interest in replacing steel springs with fiberglass composite leaf springs due to their high strength-to-weight ratio. This work deals with the replacement of a conventional steel leaf spring with a mono-composite leaf spring using E-glass/epoxy resin[8]. The design parameters were selected and analyzed with the aim of minimizing the weight of the composite leaf spring compared to the steel leaf spring. The crossbow was model in Pro/E and the analysis was performed with ANSYS Metaphysics software[9].

6- Reducing weight while increasing or maintaining product strength is becoming a very important research topic in our modern world. Composites are one of the families of materials that are attracting researchers and offering solutions to this problem. In this article we describe the design and analysis of composite leaf springs. A rear leaf spring for MAHINDRA "MODEL-COMMANDER 650 DI" can be considered [10]. The aim is to compare the stresses, deflections and weight savings of composite leaf springs with those of steel leaf springs. The design constraint is rigidity.

The au tomotive industry has a keen interest in replacing steelleaf springs with composite leaf springs because of the high strength-to-weight ratio of composite materials and good corrosion resistance [11]. A glass fiber reinforced polymer (E-glass/epoxy resin) was chosen as the material, which is used in contrast to conventional steel. Design parameters were selected and analyzed with the aim of minimizing the weight of the composite leaf spring compared to the steel leaf spring. The result shows that the weight of the compound crossbow has been reduced by almost up to 85% compared to the steel material. The crossbow was model in Pro/ENGINEER and analysed with ANSYS 12.0 software. The fatigue life of steel and composite panels is compared using ANSYS software [12].

III. DESIGN PROCEDURE

Solid works is a solid modelling computer-aided design and computer-aided engineering software program that runs on Microsoft Windows. When solid works is first opened, you have to open a part, assembly or drawing. When a new part is opened, there is a blank work area on the right and a column on the left called the Feature Manager.

In the Feature Manager, there are the three main planes listed – front, top and right[13]. To begin a sketch, a plane to draw on must be selected. Right click on the desired plane and select the sketch icon in the fly-out menu. For the first sketch the view will rotate so that you are looking perpendicular to the plane you selected. The first feature sketched is called the base feature. Added on features are called boss or cut features. These add or subtract material to create the part. It is best to keep the geometry of each feature as simple as possible. Create a part with a large number of simple features rather than a few complex ones. Your work will be much easier to perform and less prone to errors in the long run[14]..

IV. MODELING METHODOLOGY

Solid works is a solid modeller, and utilizes a parametric feature-based approach to create models and assemblies. The software is written on Para solid-kernel. Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allow them to capture design intent. Design intent is how the creator of the part wants it to respond to changes and updates. For example, you would want the hole at the top of a beverage can to stay at the top surface, regardless of the height or size of the can. Solid works allows the user to specify that the hole is a feature on the top surface, and will then design intent no matter what height they later assign to the can. Features refer to the building blocks of the part[15].. They are the shapes and operations that construct the part. Shape-based features typically begin with a 2D or 3D sketch of shapes such as bosses, holes, slots, etc. This shape is then extruded or cut to add or remove material from the part. Operation-based features are not sketch-based, and include features such as fillets, chamfers, shells, applying draft to the faces of a part, etc. Building a model in solid works usually starts with a 2D sketch (although 3D sketches are available for power users). The sketch consists of geometry such as points, lines, arcs, conics (except the hyperbola), and splines.

V. RESULTS AND DISCUSSION

The structural analysis is a mathematical algorithm process by which the response of a structure to specified loads and actions is determined. This response is measured by determining the internal forces or stress resultants and displacements or deformations throughout the structure. The structural analysis is based on engineering mechanics, mechanics of solids, laboratory research, model and prototype testing, experience and engineering judgment. The basic methods of structural analysis are flexibility and stiffness methods. The flexibility method is also called force method and compatibility method. The stiffness method is also called displacement method and equilibrium method. These methods are applicable to all type of structures; however, here only skeletal systems or framed structures will be discussed. The examples of such structures are beams, arches, cables, plane trusses, space trusses, plane frames, plane grids and space frames. The skeletal structure is one whose members can be represented by lines possessing certain rigidity properties. These one dimensional members are also called bar members because their cross sectional dimensions are small in comparison to their lengths. The skeletal structures may be determinate or indeterminate.

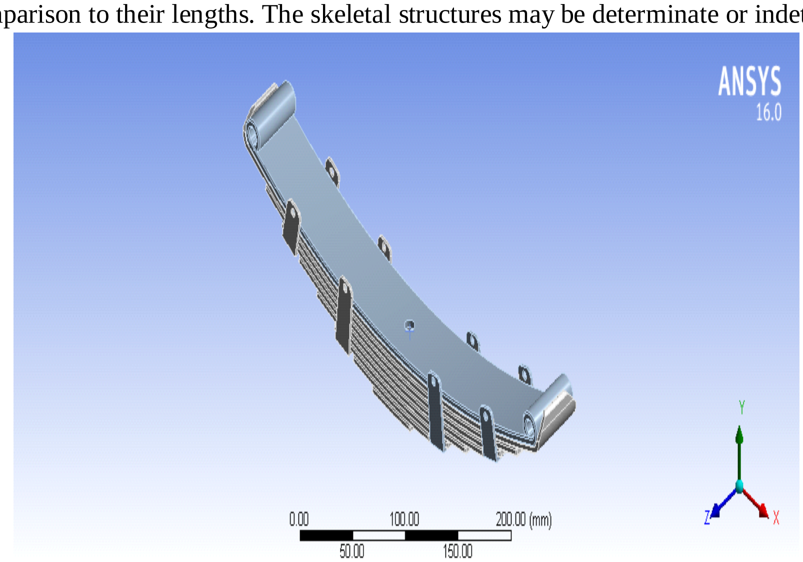

Fig.1 The leaf spring model is imported in ANSYS workbench environment

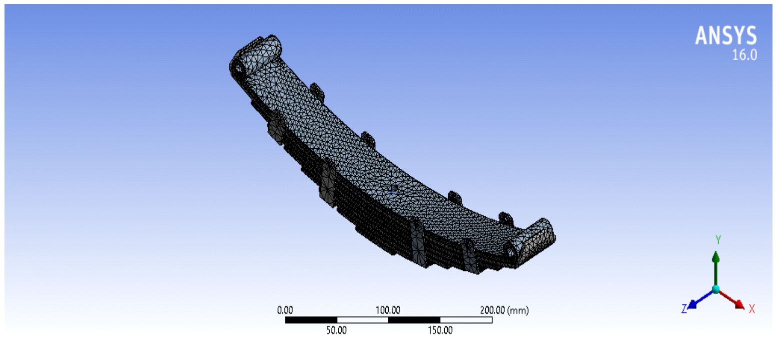

Fig.2 The meshed model of a leaf spring

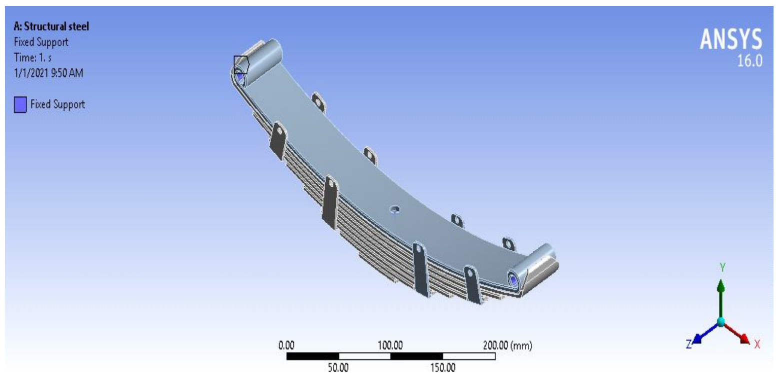

Fig.3 The fixed support is applied on two mounting ends

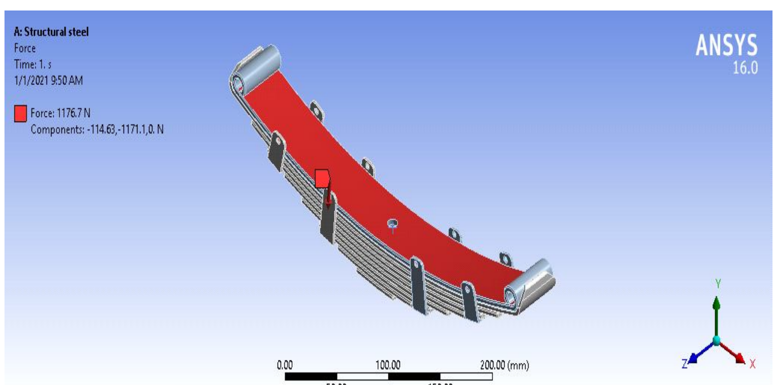

Fig.4 The load is applied as UDL on the surface of leaf spring

A. *Material in Structural Steel Results*

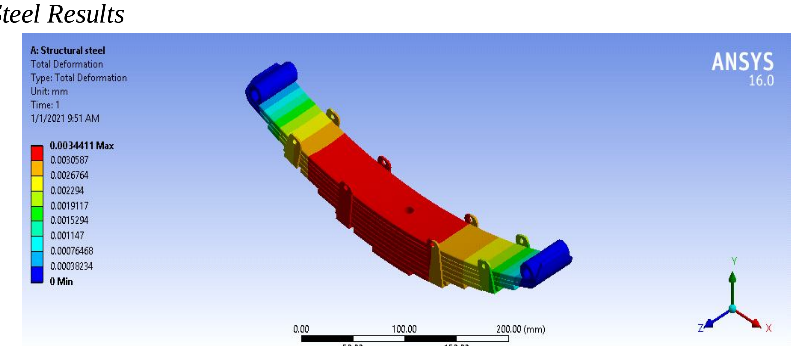

Fig.5 Total deformation Analysis

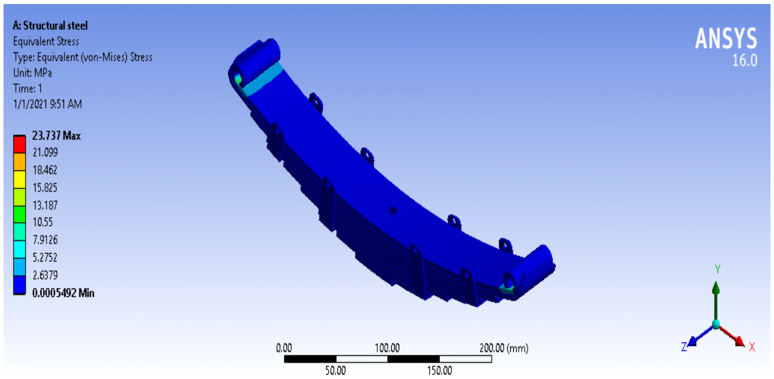

Fig.6 Stress distribution Analysis

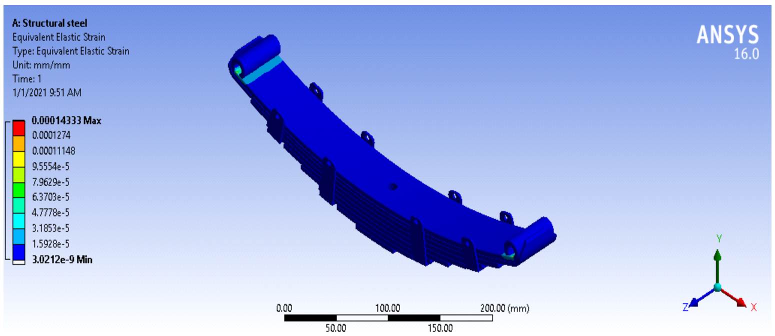

Fig.7 Strain distribution Analysis

B. Material in Chromium Vanadium Steel Results

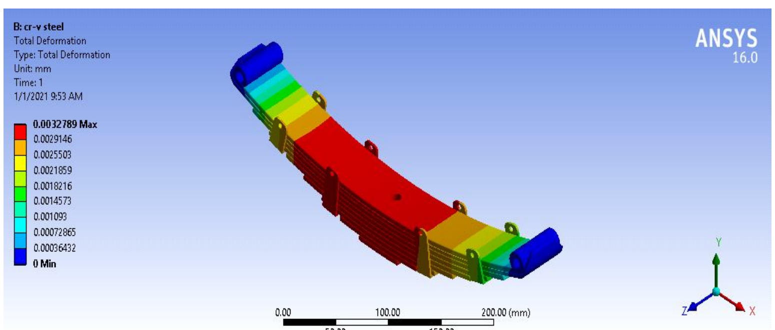

Fig.8 Total Deformation Analysis

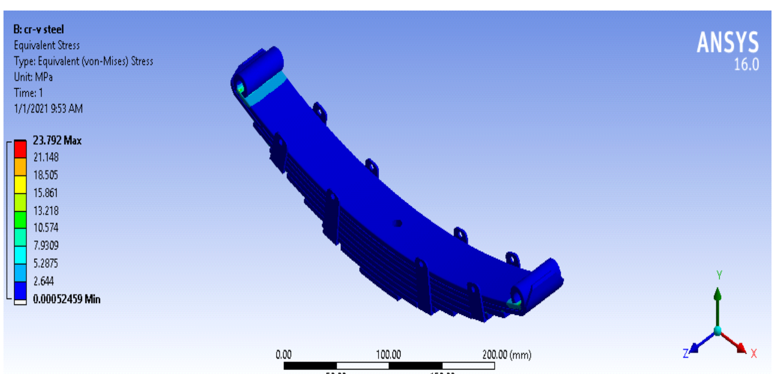

Fig.9 Stress Distribution Analysis

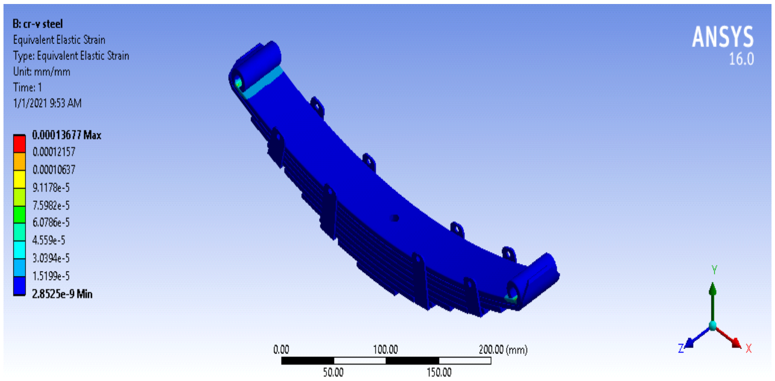

Fig.10 Strain Distribution Analysis

VI. CONCLUSIONS

1) The design and static structural analysis of steel leaf spring and steel alloy leaf spring has been carried out.
2) Comparison has been made between alloy leaf spring with steel leaf spring having same design and same load carrying capacity.
3) The stress and displacements have been calculated using ANSYS for steel leaf spring and alloy leaf spring.
4) From the static analysis results it is found that there is a maximum displacement in the steel leaf spring and the corresponding displacements in structural steel and chromium vanadium steel respectively.
5) From the static analysis results, it also seen that the von-mises stress in the steel leaf spring 23.83 MPa and 23.8 MPa respectively.
6) All the four alloy leaf springs have allowable stresses when compared to existing steel leaf spring.
7) Also the comparative study has been made between steel and alloy leaf spring with respect to strength and weight. From the above results Chromium Vanadium steel is considered to be the best replacement material over steel leaf spring.

VII. ACKNOWLEDGEMENT

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