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Finite Element Analysis Heavy Vehicle Leaf Spring: A Review

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Abstract: Fuel efficiency and emission gas regulation of automobiles are two important issues. To fulfill this problem the automobile industries are trying to make new vehicle which can provide high efficiency with low cost. The best way to increase the fuel efficiency is to reduce the weight of the automobile. The weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. The achievement of weight reduction with adequate improvement of mechanical properties has made composite a very good replacement material for conventional steel. Out of many components of automobile, the leaf spring which is required to carry out the whole weight of the vehicle is the best option for replacement of steel material by composite material. FEA analysis would be conveniently used for the analysis. Methodology for the analysis and on the composite material study is carried through literature.

Keywords: Leaf spring, FEA Analysis of leaf spring.

I. INTRODUCTION

Suspension is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels. Suspension systems serve a dual purpose – contributing to the car's road holding/handling and braking for good active safety and driving pleasure, and keeping vehicle occupants comfortable and reasonably well isolated from road noise, bumps, and vibrations, etc. These goals are generally at odds, so the tuning of suspensions involves finding the right compromise. It is important for the suspension to keep the road wheel in contact with the road surface as much as possible, because all the forces acting on the vehicle do so through the contact patches of the tires. The suspension also protects the vehicle itself and any cargo or luggage from damage and wear.

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 to as a 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. For very heavy vehicles, a leaf spring can be made from several leaves stacked on top of each other in several layers, often with progressively shorter leaves. Leaf springs can serve locating and to some extent damping as well as springing functions. While the interleaf friction provides a damping action, it is not well controlled. For this reason some manufacturers have used mono-leaf springs.

A leaf spring can either be attached directly to the frame at both ends or attached directly at one end, usually the front, with the other end attached through a shackle, a short swinging arm. The shackle takes up the tendency of the leaf spring to elongate when compressed and thus makes for softer springiness. Some springs terminated in a concave end, called a spoon end (seldom used now), to carry a swiveling member. The schematic layout of the leaf spring suspension system is shown in Fig. 1.1

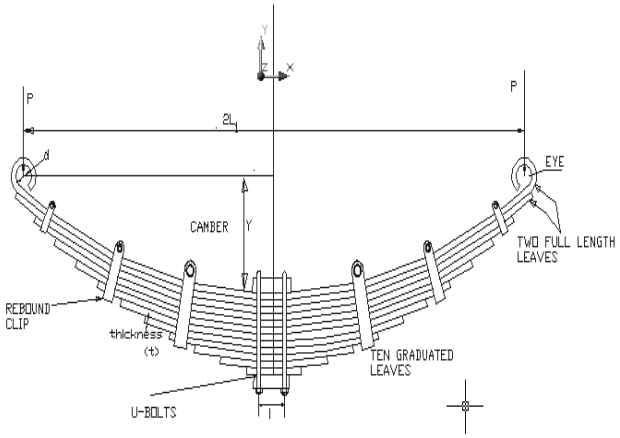

Figure 1.1 Leaf Spring Suspension System

A leaf spring commonly used in automobiles is of semi-elliptical form as shown in figure 1.1 It is built up of a number of plates (known as leaves). The leaves are usually given an initial curvature or cambered so that they will tend to straighten under the load. The leaves are held together by means of a band shrunk around them at the centre or by a bolt passing through the center. Since the band exerts stiffening and strengthening effect, therefore the effective length of the spring for bending will be

overall length of the spring minus width of band. In case of a centre bolt, two-third distance between centers of U-bolt should be subtracted from the overall length of the spring in order to find effective length. The spring is clamped to the axle housing by means of U-bolts.
The longest leaf known as main leaf or master leaf has its ends formed in the shape of an eye through which the bolts are passed to secure the spring to its supports. Usually the eyes, through which the spring is attached to the hanger or shackle, are provided with bushings of some antifriction material such as bronze or rubber. The other leaves of the spring are known as graduated leaves. In order to prevent digging in the adjacent leaves, the ends of the graduated leaves are trimmed in various forms. Since the master leaf has to with stand vertical bending loads as well as loads due to sideways of the vehicle and twisting, therefore due to the presence of stresses caused by these loads, it is usual to provide two full length. Rebound clips are located at intermediate positions in the length of the spring, so that the graduated leaves also share the stresses induced in the full length leaves when the spring rebounds.

II. LITERATURE REVIEW

Pankaj Saini, Ashish Goel & Dushyant Kumar [1] carried work on the important research issue of reducing weight while increasing or maintaining strength of products in this modern world. Composite materials are one of the material families which are attracting researchers and being solutions of such issue. In this paper we describe design and analysis of composite leaf spring. The objective is to compare the stresses and weight saving of composite leaf spring with that of steel leaf spring. The design constraint is stiffness. The Automobile Industry has great interest for replacement of steel leaf spring with that of composite leaf spring, since the composite materials has high strength to weight ratio, good corrosion resistance. The material selected was glass fiber reinforced polymer (E-glass/epoxy), carbon epoxy and graphite epoxy is used against conventional steel. The design parameters were selected and analyzed with the objective of minimizing weight of the composite leaf spring as compared to the steel leaf spring. The leaf spring was modeled in Auto-CAD 2012 and the analysis was done using ANSYS 9.0 software.

K. Viswanatham & H. Raghavendra Rao [2] carried work on optimization of heavy vehicle suspension system using composites. 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. There are mono leaf springs, or single-leaf springs, that consist of simply one plate of spring steel. These are usually thick in the middle and taper out toward the end, and they don't typically offer too much strength and suspension for towed vehicles. Drivers looking to tow heavier loads typically use multi leaf springs, which consist of several leaf springs of varying length stacked on top of each other. The shorter the leaf spring, the closer to the bottom it will be, giving it the same semielliptical shape a single leaf spring gets from being thicker in the middle. The automobile industry has shown increased interest in the replacement of steel spring with fiberglass composite leaf spring due to high strength to weight ratio. In this thesis a leaf spring used in a heavy vehicle is designed. While designing leaf spring following four cases are considered: by changing the thickness, changing no. of leaves, changing camber and changing span .Present used material for leaf spring is Mild Steel. The objective of this thesis is to compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. The design constraints are stresses and deflections. In this thesis, the material is replaced with composites since they are less dense than steel and have good strength. The strength validation is done using FEA software ANSYS by structural analysis. Modal analysis is also done to determine the frequencies. Analysis is done by layer stacking method for composites by changing number of layers 3, 5, 11 and 23. The composites used are Aramid Fiber and Glass Fiber.

B.Vijaya Lakshmi & I. Satyanarayana [3] carried static and dynamic analysis on composite leaf spring in heavy vehicle. 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. There are monoleaf springs, or single-leaf springs, that consist of simply one plate of spring steel. These are usually thick in the middle and taper out toward the end, and they don't typically offer too much strength and suspension for towed vehicles. Drivers looking to tow heavier loads typically use multileaf springs, which consist of several leaf springs of varying length stacked on top of each other. The shorter the leaf spring, the closer to the bottom it will be, giving it the same semielliptical shape a single leaf spring gets from being thicker in the middle. The objective of this paper is to compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. The design constraints are stresses and deflections. The dimensions of an existing conventional steel leaf spring of a Heavy commercial vehicle are taken Same dimensions of conventional leaf spring are used to fabricate a composite multi leaf spring using E-GLASS/EPOXY, C- GLASS/EPOXY, S-GLASS/EPOXY unidirectional laminates. Pro/Engineer software is used for modeling and COSMOS is used for analysis. Static & Dynamic analysis of Leaf spring is performed using COSMOS.

T.N.V.Ashok Kumar, E.Venkateswara Rao & S.V.Gopal Krishna [4] worked on design and material optimization of heavy vehicle leaf spring. The Automobile Industry has shown increase interest for replacement of steel leaf spring with that of composite leaf spring, since the composite material has high strength to weight ratio, good corrosion resistance. The paper describes static and dynamic analysis of steel leaf spring and laminated composite Multi leaf spring. The objective is to compare displacement, frequencies, deflections and weight savings of composite leaf spring with that of steel leaf spring. The dimensions of

an existing conventional steel leaf spring of a Light design calculations. Static and Dynamic Analysis of 3-D model of conventional leaf spring is performed using ANSYS 10.0. Same dimensions are used in composite multi leaf spring using S2 Glass/Epoxy and Kevlar/Epoxy unidirectional laminates. Analysis is done by layer stacking method for composites by changing reinforcement angles for 3 layers, 5 layers and 11 layers. The weight of composite leaf spring is compared with that of steel leaf spring. The design constraints are stresses and deflection. A weight reduction of 27.5 % is achieved by using composite leaf spring.

Shahrukh Shamim & Jamil Anwer [5] carried design and optimization of automotive multi-leaf spring by finite element method. The automobile industry has shown increased interest in the replacement of steel spring with fibre glass composite leaf spring due to high strength to weight ratio. The present study describes design and comparative analysis of multi-leaf spring made of three different materials. The modeling of the leaf spring has been done in commercially used FEM software ANSYS 14.0, and for finite element analysis the model was imported in the Static Structural analysis and Harmonic Response workbench of ANSYS 14.0. The Materials used for the multi-leaf spring is AISI 6150 Steel (Oil Quenched 845°C and 650°C tempered), Ti-6Al-4V alloy and S-Glass fiber Composite. Harmonic analysis for vibrations due to road irregularity is carried out for all the materials. Von-Mises stress and deformation is the output parameters in static structural analysis.

A.Seshagiri Rao & D.Devsing [6] carried optimization of heavy vehicle suspension system using composites. 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. There are mono leaf springs, or single-leaf springs, that consist of simply one strip of spring steel. These are usually thick in the middle and taper out toward the end, and they don't typically offer too much strength and suspension for towed vehicles. Drivers looking to tow heavier loads typically use multi leaf springs, which consist of several leaf springs of varying length stacked on top of each other. The shorter the leaf spring, the closer to the bottom it will be, giving it the same semielliptical shape a single leaf spring gets from being thicker in the middle. The automobile industry has shown increased interest in the replacement of steel spring with fiberglass composite leaf spring due to high strength to weight ratio .In this paper a leaf spring used in a heavy vehicle is designed. While designing leaf spring following four cases are considered: by changing the thickness, changing no. of leaves, changing camber and changing span. Presently used material for leaf spring is Steel. The objective of this paper is to compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. The design constraints are stresses and deflections. In this thesis, the material is replaced with composites since they are less dense than steel and have good strength. The strength validation is done using FEA software ANSYS by structural analysis. Modal analysis is also done to determine the frequencies. The composites used are Aramid Fiber and Glass Fiber. Pro/Engineer software is used for modeling and ANSYS is used for analysis.

III. CONCLUSION

The review is carried out on the recent research on the Heavy vehicle leaf spring. Different composite materials can be used and the necessary weight reduction can be accomplish. For the analysis both the static and dynamic consideration have to be taken into considerations. For solid modelling pro-engineer or CATIA can be used. The strength validation can be done using FEA software which is available in ANSYS and can be done by structural analysis.

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