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Optimization Of Heavy Vehicle Suspension System Using Composites

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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. 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.

***Keywords: Heavy Vehicle**, Suspension system, Composites, optimizations.*

1. Introduction

Semi-elliptic leaf springs are almost universally used for suspension in light and heavy commercial vehicles. For cars also, these are widely used in rear suspension

The spring consists of a number of leaves called blades. The blades are varying in length. The blades are us usually given an initial curvature or cambered so that they will tend to straighten under the load. The leaf spring is based upon the theory of a beam of uniform strength. The lengthiest blade has eyes on its ends. This blade is called main or master leaf, the remaining blades are called graduated leaves. All the blades are bound together by means of steel straps.

The spring is mounted on the axle of the vehicle. The entire vehicle load is rests on the leaf spring. The front end of the spring is connected to the frame with a simple pin joint, while the rear end of the spring is connected with a shackle. Shackle is the flexible link which connects between leaf spring rear eye and frame. When the vehicle comes across a projection on the road surface, the wheel moves up, this leads to deflecting the spring. This changes the length between the spring eyes.

The automobile chassis is mounted on the axles, not direct but some form of springs. This is done to isolate the vehicle body from the road shocks, which may be in the form of bounce, pitch, roll or sway. These tendencies give rise to an uncomfortable ride and also cause additional stress in the automobile frame anybody. All the part, which performs the function of isolating the automobile from the road shocks, is collectively called a suspension system. It includes the springing device used and various mountings for the same.

Broadly speaking, suspension system consists of a spring and a damper. The energy of road shock causes the spring to oscillate. These oscillations are restricted to a reasonable level by the damper which is more commonly called a shock absorbers

2 Materials

Aramid fibers are a class of heat-resistant and strong synthetic fibers. They are used in aerospace and military applications, for ballistic rated armor fabric and ballistic composites, in bicycle tires, and as an asbestos substitute. The name is a portmanteau of "aromatic polyamide". They are fibers in which the chain molecules are highly oriented along the fiber axis, so the strength of the chemical bond can be exploited

Glass fiber (also spelled glass fibre) is a material consisting of numerous extremely fine fibers of glass. Glassmakers throughout history have experimented with glass fibers, but mass manufacture of glass fiber was only made possible with the invention of finer machine tooling. In 1893, Edward Drummond Libbey exhibited a dress at the World's Columbian Exposition incorporating glass fibers with the diameter and texture of silk fibers. This was first worn by the popular stage actress of the time Georgia Cayvan. Glass fibers can also occur naturally, as Pele's hair. Glass wool, which is commonly known as "fiberglass" today, however, was invented in 1938 by Russell Games Slayter of Owens-Corning as a material to be used as insulation. It is marketed under the trade name Fiberglas, which has become a generalized trademark

3.Design of Leaf spring

Pro/ENGINEER Wildfire is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated Pro/ENGINEER CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products.

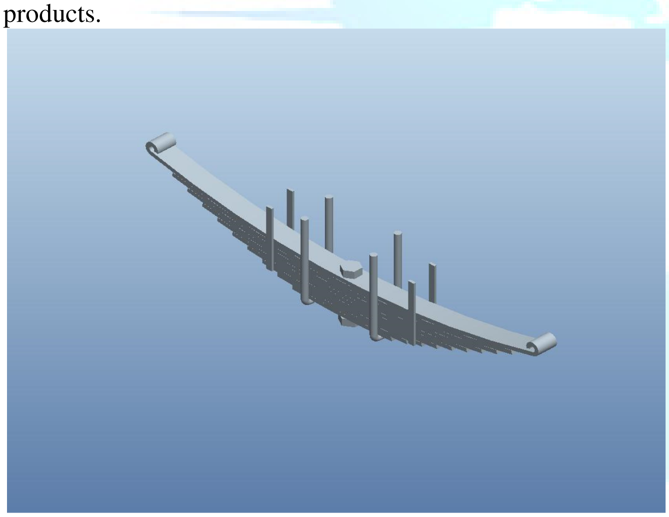

Fig 1 Leaf spring

4.Finite Element Analysis Results

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

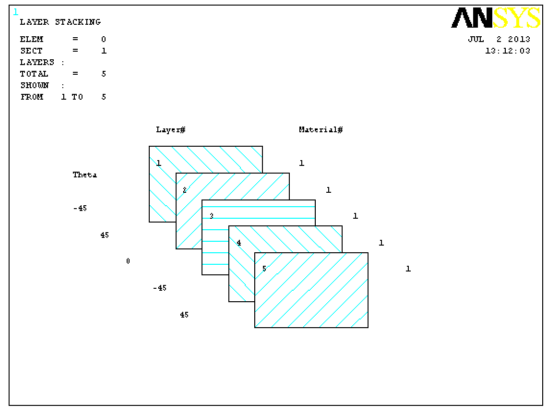

Fig 2 Armed fiber 5 layers

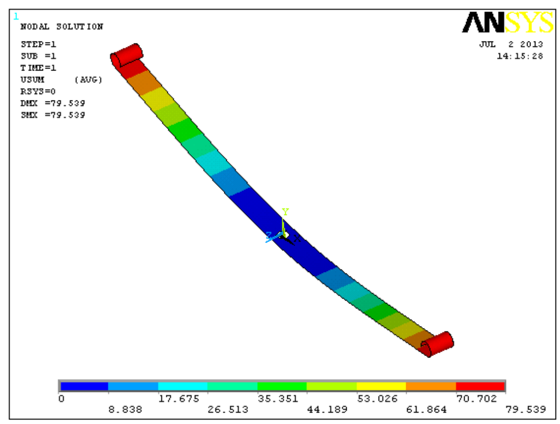

Fig 3 Displacements

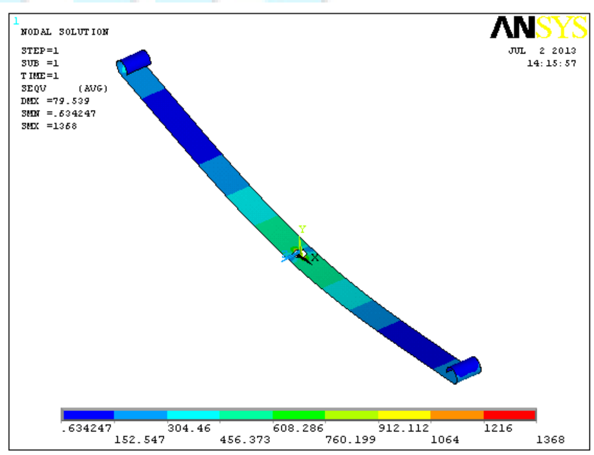

Fig 4 Von mises stress diagram

	STEEL	ARAMID FIBER	GLASS FIBER
DISPLACEMENT (mm)	68.576	79.538	161.411
STRESS (N/mm^2)	1365	1368	1371
ALLOWABLE STRESS (N/mm^2)	1600	3450	4135

Table 1 Structural analysis results of 23 layers

		STEEL	ARAMID FIBER	GLASS FIBER
MODE1	**Hz**	0.62896	1.352	0.719204
	Deflection (mm)	0.389107	0.901042	0.682535
MODE 2	**Hz**	0.630157	1.355	0.72003
	Deflection (mm)	0.389157	0.901519	0.682685
MODE 3	**Hz**	2.279	4.896	2.606
	Deflection (mm)	0.40882	0.945113	0.718349

Table 2 Modal analysis results of 23 layers

5.Conclusions

In this paper, a leaf spring is designed for Ashok Leyland Viking heavy vehicle. The data is collected from net for the specifications of the model. The leaf spring is designed for the load of 14087.5N. Theoretical calculations have been calculated for leaf spring dimensions at different cases like varying thickness, camber, span and no. of leaves by mathematical approach. In this thesis, analysis has been done by taking material Steel, Aramid Fiber and Glass Fiber.

Structural and modal analysis are conducted on single leaf by using layer stacking analysis, this analysis is done for only composites. The results show:
1.The stresses in the composite leaf spring of design are much lower than that of the allowable stress.
2.The strength to weight ratio is higher for composite leaf spring than conventional steel spring with similar design.

By observing the structural analysis result, using Aramid Fiber is better than Glass Fiber since the stresses are less. But if we consider Frequency analysis, using Glass fiber is better since the frequencies are less, there by reducing the vibrations.

In this paper it can be concluded that using composite Aramid Fiber is advantageous since the weight and the stresses are less. Composite leaf springs made of polymer matrix composites have high strength retention on ageing at severe environments.

Structural and modal analysis are conducted on the master leaf for single, 3 layers and 5 layers,11 layers, 23 layers. From the results observed, if number of layers is increased for same thickness the vibrations are less. By reducing the vibrations, increase component life can be increased because more number of vibrations will cause sudden failure of springs because springs are like simply supported beam

The steel leaf spring width is kept constant and variation of natural frequency with leaf thickness, span, camber and numbers of leaves are studied. It is observed from the present work that the natural frequency increases with increase of camber and almost constant with number of leaves, but natural frequency decreases with increase of span. The natural frequencies of various parametric combinations are compared with the excitation frequency for different road irregularities. The values of natural frequencies and excitation frequencies are the same for both the springs as the geometric parameters of the spring are almost same except for number of leaves.

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