

Static Deformation Analysis of Leaf Spring used in Heavy Load Vehicles

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Abstract—This project deals with parabolic leaf spring simulation using nonlinear static, rigid and flexible dynamics combination. The model of the leaf spring is designed using CREO software, and the systematic analysis of the designed model is done using ANSYS software. The model selected is parabolic leaf spring. In this model 7 leaves are been used and material is used commonly for the leaf spring is steel (conventional material), here we have to modify the material like e glass epoxy and carbon fiber. The leaf spring is commonly used for the suspension in wheeled vehicles. The advantage of a leaf spring over other suspension system is that the end of the leaf spring can be guided along a definite path. The modeling of the leaf spring is done and using the analyzing software analyzing process is done. Here we are using nonlinear static, rigid and flexible dynamics combination analysis. At last the results are tabulated. The part modeling is done by using CREO and the assembly is also done by the same software. This will also help us to learn the 3D modeling software and the analyzing software.

I. INTRODUCTION

One of the main components of automobile that provide a good suspension and plays vital role in automobile application is Leaf Spring. It carries lateral loads, brake torque, driving torque in addition to shock absorbing. The advantage of leaf spring over other suspension system is that the ends of the spring may be guided along a definite path as the spring deflects to act as a structural member in addition to energy absorbing device. Composite material technology is used by automobile industries for structural components to obtain the reduction of weight without decreasing vehicle quality and reliability. Energy conservation is one of the most important objectives in any vehicle design and reduction of weight is one of the most effective measures for energy conservation as it reduces overall fuel consumption of the vehicle. In automobiles ten to twenty percent of the un-sprung weight is due to leaf spring suspension system. The leaf spring should absorb shocks, vertical vibrations and bump loads by means of spring deflection so that the potential energy stored in the leaf spring is converted to strain energy and then released slowly. While selecting the material for leaf spring elastic strain energy storage capacity of material is considered as main criteria.

II. OBJECTIVE

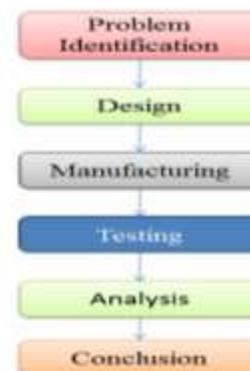
The main focus of automobile manufacturers in the present era is to safeguard natural resources and economize energy. Weight reduction and less cost has been the main objective of any modulation work carried out in a particular component. The introduction of better material, design optimization and

better manufacturing processes can result in reducing the weight of the vehicle. Ten to twenty percent of the un-sprung weight of automobile is due to the leaf spring suspension system. Leaf springs are widely used in the suspension system of heavy vehicles and it is subjected to absorb the shock bump loads (induced due to road irregularities) and vehicle vibrations by means of spring deflection. The aim of this paper is to present a study on the design and analysis of leaf spring.

III. COMPONENTS OF SUSPENSION SYSTEM

The method developed, especially nonlinear analysis, makes it possible to accurately design leaf springs. A research using nonlinear analysis to solve leaf spring problem was discussed by Liu, however, only single leaf spring model was considered. The purpose of design development for the suspension springs are not only to reduce weight and vibration for a soft ride, improve durability when subjected to cyclic loading, or improve quality of spring material and processing, but also to reduce time and manufacturing cost in the design process to gain the highest economic benefit. Computer technology in terms of CAD/CAE (Computer-Aided Design and Engineering) has been applied to solve engineering problems for several decades. Finite element method is an effective part of CAD/CAE applied in design and analysis to solve complicated problems. The purposes of this research are to analyze, develop and validate finite element models of multi-leaf spring by comparing to experimental data for the advantage of product design process.

IV. METHODOLOGY



V. CALCULATIONS

a) Deflection of the Spring

- Overall length of the leaf spring, $2L = 1000\text{ mm}$;
- $L = 500\text{ mm}$
- Total no. of leaves, $n = 7$
- Load on the spring, $P = 8000\text{ N}$
- No. of graduated leaves, $n_g = n - n_f$
 $= 8 - 1 = 7\text{ nos}$

Where, $n_f = \text{No. of full length leaves}$

- Width of the leaves, $b = 90\text{ mm}$
- Thickness of the leaf $t = 10\text{ mm}$
- $E = \text{Young's modulus of material} = 2.1 \times 10^5\text{ N/mm}^2$
- Deflection of the spring,

$$y = \frac{18 P L^3}{E b t^3 (3 n_f + 2 n_g)}$$

$$= \frac{18 \times 8000 \times 500^3}{2.1 \times 10^5 \times 90 \times 10^3 (3 \times 1 + 2 \times 7)}$$

$$= 1.8/3.213$$

$$= 5.602\text{ mm}$$

B) Stiffness of the Spring

- Stiffness = k
- Young's models = $E = 2.1 \times 10^5$
- Number of leaves = $n = 7$
- Width of the leaf = $b = 90$
- Thickness of the leaf spring = $t = 10$
- Length of the leaf spring = $l = 1000/2 = 500$

$$K = \frac{8 x E x n x b x t^3}{3 x L^3}$$

$$= \frac{8 \times 2.1 \times 10^5 \times 7 \times 90 \times 10^3}{3 \times 500^3}$$

$$= 2822.4\text{ Nm}^{-1}$$

VI. MATERIAL SELECTION

A) 60Si7 STEEL

60Si7 is the most popular grade of spring steel being used in automobile leaf spring. So the test steel leaf spring used for experiment is made up of 60Si7. The composition of material is 0.56 C%, 1.80 Si%, 0.70 Mn%, 0.045 P%, 0.045 S%.

Young's modulus	2.1e5 MPa
Poisson's ratio	0.266
Density	7860 kg/m ³

Shear modulus	78989 MPa
Bulk modulus	1.4245e5 MPa

B) E Glass/ Epoxy

The most common types of glass fiber used in fiberglass is E-glass, which is alumino-borosilicate glass with less than 1% w/w alkali oxides, mainly used for glass-reinforced plastics like epoxy. Fiberglass is a type of fiber reinforced plastic where the reinforcement fiber is specifically glass fiber. The glass fiber may be randomly arranged but is commonly woven into a mat. The plastic matrix may be a thermosetting plastic- most often epoxy.

Young's modulus	24000 MPa
Poisson's ratio	0.3
Density	1520 kg/m ³
Shear modulus	28991 MPa
Bulk modulus	50484 MPa

C) Carbon Fibre

The raw material used to make carbon fiber is called the precursor. About 90% of the carbon fibers produced are made from polyacrylonitrile. The remaining 10% are made from rayon or petroleum pitch.

Young's modulus	3.5e5 MPa
Poisson's ratio	0.30
Density	1950 kg/m ³
Shear modulus	78989 MPa
Bulk modulus	1.4245e5 MPa

VII. STATIC STRUCTURAL ANALYSIS

The method developed, especially nonlinear analysis, makes it possible to accurately design leaf springs. A research using nonlinear analysis to solve leaf spring problem was discussed by Liu, however, only single leaf spring model was considered. The purpose of design development for the suspension springs are not only to reduce weight and vibration for a soft ride, improve durability when subjected to cyclic loading, or improve quality of spring material and processing, but also to reduce time and manufacturing cost in the design process to gain the highest economic benefit.

The static structural analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. The types of loading that can be applied in a static analysis include:

- ✓ Externally applied forces and pressures

- ✓ Steady-state inertial forces
- ✓ Imposed (nonzero) displacements
- ✓ Temperatures (for thermal strain)

VIII. COMPARISION OF RESULT

A) 60Si7 STEEL

	MIN	MAX
Total deformation (mm)	0	1.801
Equivalent elastic strain (mm/mm)	0	0.00205
Equivalent stress (MPa)	0	383.99

B) E GLASS/ EPOXY

	MIN	MAX
Total deformation (mm)	0	1.57
Equivalent elastic strain (mm/mm)	0	0.00178
Equivalent stress (MPa)	0	383.51

C) CARBON FIBRE

	MIN	MAX
Total deformation (mm)	0	1.648
Equivalent elastic strain (mm/mm)	0	0.000105
Equivalent stress (MPa)	0	336.06

IX. CONCLUSION

Analyzing results for leaf spring under force are listed in the Table. Analysis has been carried out by 60Si7 steel

(conventional material) and optimizing the materials i.e., E glass epoxy, carbon fiber. The results such as total deformation, equivalent elastic strain and equivalent stress for each material are determined. Comparing the optimized materials and the conventional material, E glass epoxy composite material has the low values of total deformation and strain. While using E glass epoxy weight of the leaf is reduced by 67.69%. Hence it is concluded that E glass epoxy material can be used for the leaf spring.

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