RESEARCH ARTICLE OPEN ACCESS

Design and Analysis of Leaf Spring for Material Optimization

Sk. Mohammad Shareef[1], A.L.N. Arun Kumar[2], T. Venkatesh[3]
1,2,3(Assistant Professor, Mechanical Engineering Department, CVR College of Engineering, Hyderabad)
Email: shareefshaik4@gmail.com, aln.arunkumar@gmail.com, venkatesh2711991@gmail.com

Abstract:

Reducing weight while increasing or maintaining strength of products is getting to be a highly important research issue in this modern world. This paper discuses about design and analysis of leaf spring for material optimization. The objective is to compare the stresses and weight saving of designed leaf spring with that of contemporary leaf spring. The design constraint is stiffness. The automobile Industry has great interest in replacement of contemporary leaf spring with that of leaf spring with improved properties like high strength to weight ratio, good corrosion resistance. The design parameters were selected and analyzed with the objective of minimizing weight of the designed leaf spring as compared to the steel leaf spring.

Keywords **—Design, CATIA, Leaf spring, Analysis and Material selection.**

I. INTRODUCTION

Originally called laminated or carriage spring, a leaf spring is a simple form of spring, commonly used for the suspension in wheeled vehicles. It is also one of the oldest forms of springing, dating back to medieval times. The advantage of leaf spring over helical spring is that the end of the springs may be guided along a definite path.

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 terminate in a concave end, called a spoon end (seldom used now), to carry a swiveling member. A more modern implementation is the parabolic leaf spring. This design is characterized by fewer leaves whose thickness varies from center to ends following a parabolic curve. In this design, interleaf friction is unwanted, and therefore there is only contact between the springs at the ends and at the center where the axle is connected. Spacers prevent contact at other points.

Aside from a weight saving, the main advantage of parabolic springs is their greater flexibility, which translates into vehicle ride quality that approaches that of coil springs. There is a trade-off in the form of reduced load carrying capability, however. The characteristic of parabolic springs is better riding comfort and not as "stiff" as conventional "multi-leaf

springs". It is widely used on buses for better comfort. A further development by the British GKN company and by Chevrolet with the Corvette amongst others, is the move to composite plastic leaf springs. Typically, when used in automobile suspension the leaf both supports an axle and locates/ partially locates the axle. This can lead to handling issues (such as 'axle tramp'), as the flexible nature of the spring makes precise control of the unspring mass of the axle difficult. Some suspension designs which use leaf springs do not use the leaf to locate the axle and do not have this drawback. The Fiat 128's rear suspension is an example.

Fig. 1 A traditional leaf spring arrangement

A. *Concept of Fatigue:*

In narrow sense, the term fatigue of materials and structural components means damage and damage due to cyclic, repeatedly applied stresses. In a wide sense, it includes many phenomena of delayed damage and fracture under loads and environmental conditions. It is expedient to distinguish between high-cycle (classic) and low-cycle fatigue. In material science, fatigue is the progressive, localized, and permanent structural damage that occurs when a material is subjected to cyclic or fluctuating strains at nominal stresses that have maximum values less than (often much less than) the static yield strength of the material.

II. LITERATURE REVIEW

According to the studies, a material with maximum strength and minimum modulus of elasticity in the longitudinal direction is the most suitable material for a leaf spring.

To meet the need of natural resources conservation, automobile manufacturers are attempting to reduce the weight of vehicles in recent years.

The composite materials made it possible to reduce the weight of the machine element without any reduction of the load carrying capacity. Because of composite material's high elastic strain energy storage capacity and high strength-to-weight ratio compared with those of steel.

III. METHODOLOGY

- Material selection process
- Derivation of dimensions of leaf spring for design purpose.
- Modelling of leaf spring in a CAD software.
- Finite Element Analysis is carried out by ANSYS simulation software on that model.

I. METHODOLOGY

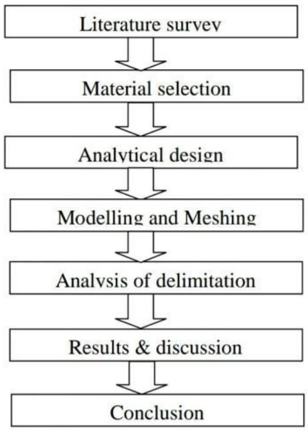


Fig. 2 Methodology flow chart

IV. EXPERIMENTAL WORK

A. *Design of leaf spring*

Thickness, Length, width, and radius of curvature of each leaf is derived for following specifications.

TABLE I
SPECIFICATIONS OF LEAF SPRING

Specifications		
1	Total Length of the Spring	1120 mm
2	Free chamber	180 mm
3	No of full-length leaves	2
4	No of graduated leaves	8
5	Thickness of the leaf	10 mm
6	Width of the leaf spring	50 mm
7	Maximum load given on spring	6685 N
8	Youngs modulus of the steel	210000(Mpa)
9	Wight of the leaf spring	17.78 Kg
10	Poisson's ratio	0.3

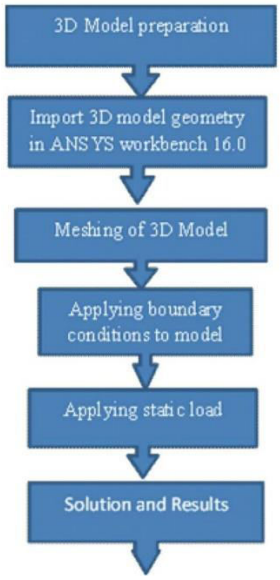
Then model is created in a Computer aided design (CAD) software.

Fig. 3 Model of leaf spring

B. Analysis of Leaf spring

General steps to solving problem in ANSYS

1. Build Geometry:
 Construct a two- or three-dimensional representation of the object to be modelled and tested using the work plane coordinate system within ANSYS.
2. Define Material Properties:
Now that the part exists, define a library of the necessary materials that compose the object (or project) being modelled. This includes thermal and mechanical properties.
3. Generate Mesh:
At this point ANSYS understands the makeup of the part. Now define how the modelled system should be broken down into finite pieces.
4. Apply Loads:
 Once the system is fully designed, the last task is to burden the system with constraints, such as physical loadings or boundary conditions.
5. Obtain Solution:
This is a step, because ANSYS needs to understand within what state (steady state, transient… etc.) the problem must be solved.



V. RESULTS

A. Structural analysis results:

For steel: Maximum deformation is 73.9mm and maximum Equivalent stress is 352.9 Mpa

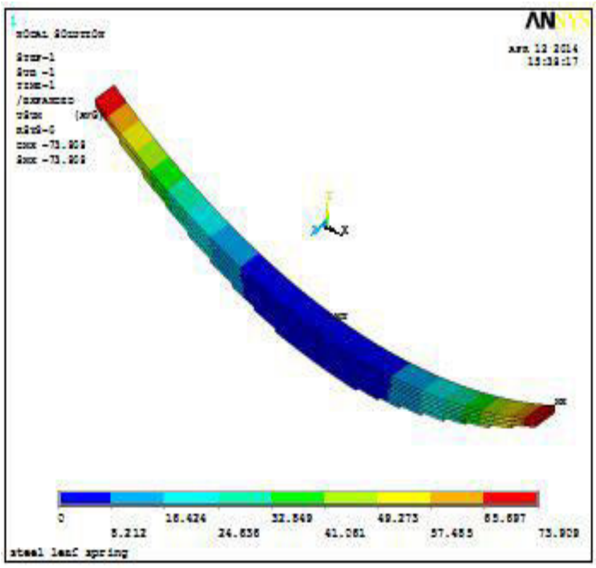


Fig. 4 Deformations in steel

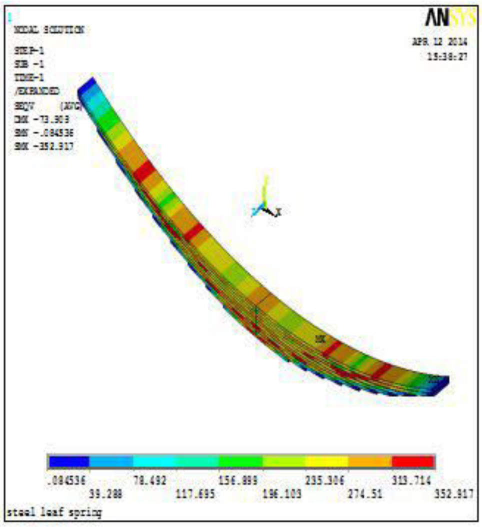


Fig. 5 Stresses in steel

For E glass/ Epoxy: Maximum deformation is 52.3mm and maximum Equivalent stress is 178.3Mpa.

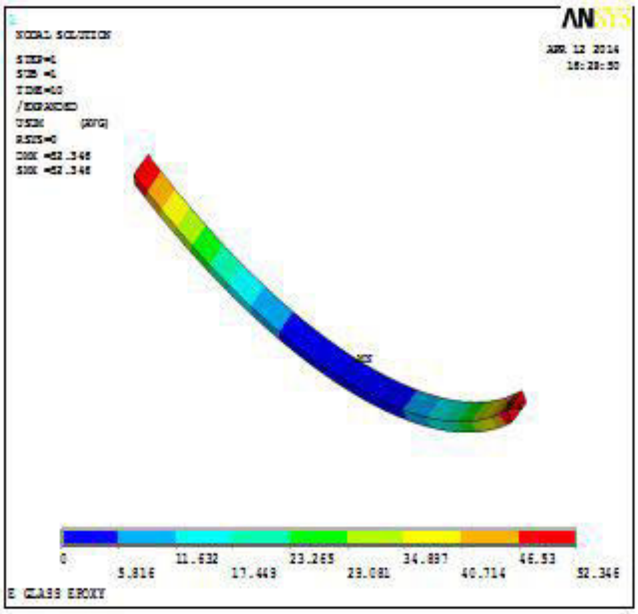


Fig. 6 Deformations in E glass / Epoxy

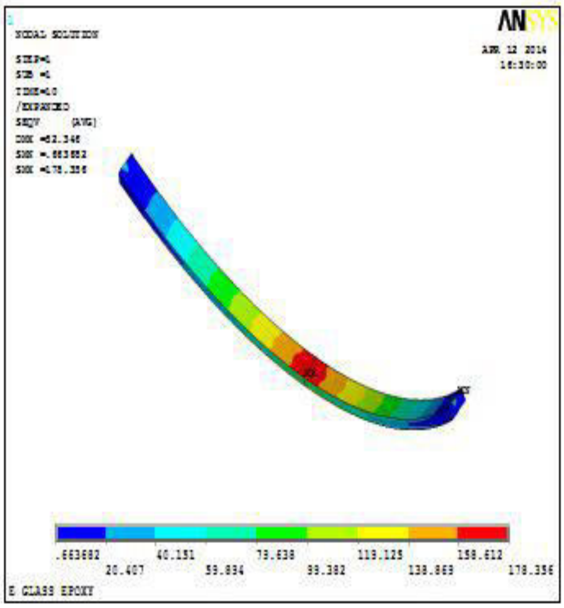


Fig. 7 Stresses in E glass / Epoxy

B. Fatigue analysis results:

For Steel:

TABLE II
FATIGUE ANALYSIS OF STEEL AT FIXED SUPPORT

Fatigue of steel at fixed					
Events	Load (N)	Applied cycles	Stress intensity in Mpa	No of Cycles	Partial Usage
1	1600	50,000	305.43	1.00E+6	0.05
2	2000	50,000	381.79	3.31E+5	0.1512
3	3000	50,000	572.69	2598	19.242
4	4000	50,000	763.59	10	5000
5	5000	50,000	954.48	10	5000

For E glass / Epoxy:

TABLE III
FATIGUE ANALYSIS OF E GLASS / EPOXY AT FIXED SUPPORT

Fatigue of E glass / Epoxy at fixed					
Events	Load (N)	Applied cycles	Stress intensity in Mpa	No of Cycles	Partial Usage
1	1600	50,000	174.33	3.12E+6	0.01603
2	2000	50,000	217.91	1.95E+6	0.02558
3	3000	50,000	326.86	6.79E+5	0.07358
4	4000	50,000	435.81	1.86E+5	0.26916
5	5000	50,000	544.77	4.71E+4	1.06121

VI. CONCLUSIONS

- It is shown that the resulting design and simulation stresses are much below the strength properties of the material satisfying the maximum stress failure criterion.

- From the static analysis results, we see that the von- mises stress in the steel is 352.917 MPa. And the von-mises stress in E Glass/Epoxy is 178.356MPa.
- Composite mono leaf spring reduces the weight by nearly 84% for E-Glass/Epoxy.
- From the fatigue analysis results, the usage factor of E Glass/Epoxy is very much less compared to steel.

Hence it is advantageous to replace steel leaf spring with E Glass/Epoxy.

REFERENCES.

1. *Rohit Gosh and Susvosh, Static Analysis of Multi leaf Spring Using Ansys Benchmark 16, Ijmet_07_05_025 Volume 7, Issue 5, Pp.241-249, September-October 2016.*
2. *Kabariya Kaushal Kanubhaii, Shyam Gupte, Design and Analysis of Automobile Leaf Spring by Changing Cross Sectional Area and Compared it with Composite Material, Ijariie- Issn (O)-2395-4396, Vol-4, Issue-1*
3. *M Rama Laxmi, R.Rudrabi Ram, Design Analysis of Leaf Spring Through Catia and Ansys with Different Composites ,Issn 2349-4476 ,Volume 3, Issue 10,October 2015*
4. *Dakshraj Kothari,Rajendra Prasad Sahu and Rajesh Satankar Comparison of Performance of Two Leaf Spring Steels Used for Light Passenger Vehicle, VSRD-MAP 2249-8303 Volume2 (1), 9-16, 2012.*
5. *Mr. V. Lakshmi Narayana, Design and Analysis of Mono Composite Leaf Spring for Suspension in Automobiles, IJERT 2278-0181, Vol. 1 Issue 6, August – 2012.*