Static and Modal Analysis of Leaf Spring using FEA

Meghavath. Peerunaik[1], Tippa Bhimasankara Rao[2] , K.N.D.Malleswara Rao[3]

[1]PG Student, Department of Mechanical Engineering, Nimra Institute of Science and Technology

[2] HOD, Department of Mechanical Engineering, Nimra Institute of Science and Technology, Vijayawada, AP, INDIA

[3]asst. Prof, Department Of Mechanical Engineering, Vikas College Of Engineering & Technology, Nunna, Ap, India

ABSTRACT

The objective of this present work is to estimate the deflection, stress and mode frequency induced in the leaf spring of an army jeep design by the ordinance factory. The emphasis in this project is on the application of computer aided analysis using finite element concept. The component chosen for analysis is a leaf spring which is an automotive component used to absorb vibrations induced during the motion of vehicle. It also acts as a structure to support vertical loading due to the weight of the vehicle and payload. Under operating conditions, the behaviour of the leaf spring s complicated due to its clamping effects and interleaf contact, hence its analysis s essential to predict the displacement, mode frequency and stresses. The leaf spring, which we are analyzing, is a specially designed leaf spring used in military jeeps. This spring is intended to bare heavy jerks and vibrations reduced during military operations. A model of such jeep has been shown in this project report. In analysis part the finite element of leaf spring is created using solid tetrahedron elements, appropriate boundary conditions are applied, material properties are given and loads are applied as per its design, the resultant deformation, mode frequencies and stresses obtained are reported and discussed.

Keywords: *ANSYS, bending moment, leaf spring, torsional moment, Pro-E.*

I. 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.

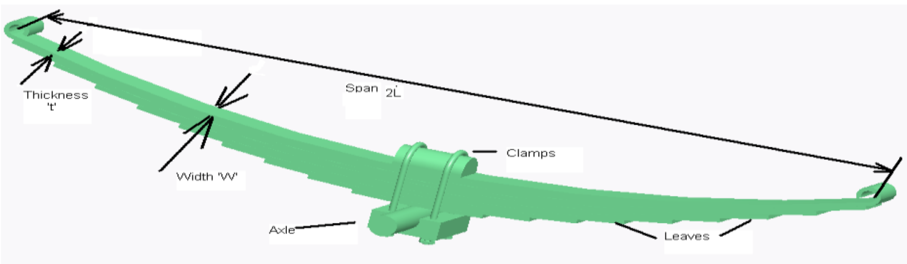

Fig.1 Elements of Leaf spring

1. **Geometric properties of leaf spring**
   Camber = 80mm
   Span = 1220mm
   Thickness = 7mm
   Width = 60mm

Number of full length leaves $n_F = 2$
Number of graduated leaves $n_G = 8$

II. MATERIAL PROPERTIES OF LEAF SPRING

Parameter	Value
Material selected – Steel	55Si2Mn90
Tensile strength (N/mm^2)	1962
Yield strength (N/mm^2)	1470
Young's modulus E (N/mm^2)	$2.1 \cdot 10^5$
Design stress (σ_b) (N/mm^2)	653
Total length (mm)	1190
The arc length between the axle seat and the front eye (mm)	595
Arc height at axle seat (mm)	120
Spring rate (N/mm)	32
Normal static loading (N)	3850
Available space for spring width (mm)	60 – 70
Spring weight (kg)	26

Table.1 material properties

Material = Manganese Silicon steel
Density = 7.86E-6 kg/mm^2
Poisson's ratio = 0.3

III. MODELING OF LEAF SPRING

Pro Engineer software was used for this particular model and the steps are as follows:

[1] Start a new part model with Metric units set.
[2] Draw the sketches of the trajectories of each leaf of spring with the radius obtained from calculations with span1220mm camber 80.
[3] Using sweep command draw a section 60 mm X 7 mm thick sweep along the above drawn curves of leaf.
[4] According the spring design manual the eye diameter is formed on the first leaf.
[5] Thickness of leaves = 7mm.
[6] After all the features of all leaves as are modeled, generate family table for each leaf.
[7] Generate models for u-clams, axle rod, top support plate etc.
[8] Assemble each of the leaf in an assembly model and assemble all other models.
[9] Provide a ½ inch dia hole in the leaf spring for bolt.
[10] Export the model to iges – solid – assembly – flat level.

IV. COMPOSITE MONO LEAF SPRING

The steps for modeling are as follows:

[1] Start a new part model with Metric units set.
[2] Draw the sketch of the trajectory with dimensions of first leaf of spring of steel spring assembly without eyes, span is same as 1220mm and camber 80.
[3] The geometrical dimensions are carried forward from the steel leaf spring except for the number of plates and thickness in order to maintain the required cross section area. Generate sketches cross section dimensions at center and ends as mentioned in table follows:
[4] Using swept blend
[5] Select trajectory
[6] Pivot direction
[7] Select plane for pivot direction
[8] Select origin trajectory
[9] Select cross section sketches. The model is ready.
[10] Export the model to iges – solid – part – flat level.

Fig.2 Model of mono composite leaf spring

V. ANALYSIS OF LEAF SPRING

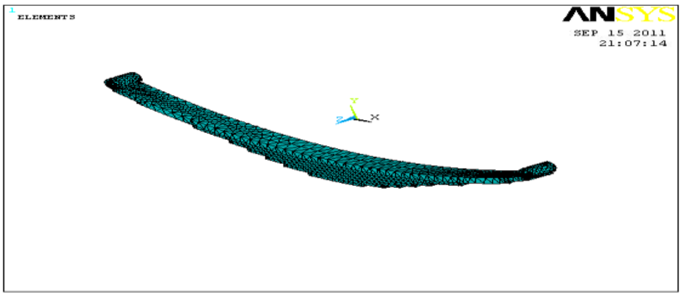

Fig.3 meshed model of leaf spring

VI. RESULTS & DISCUSSION

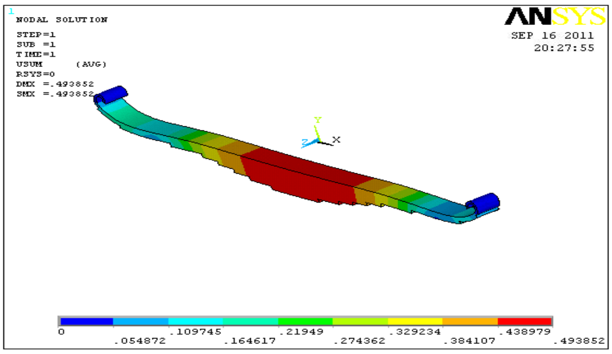

Fig.4 Distribution of Displacements plots at a load of 2000 N on steel leaf spring

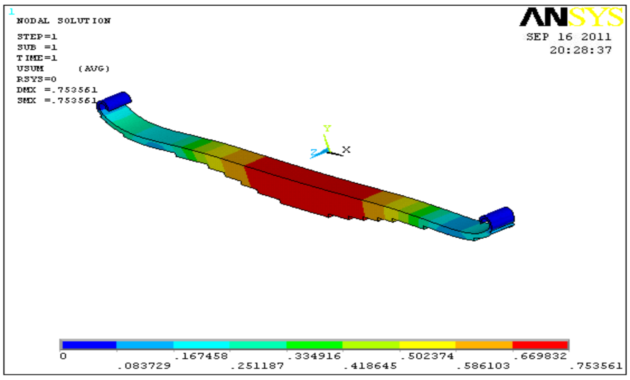

Fig.5 Distribution of Displacements plots at a load of 3000 N on steel leaf spring

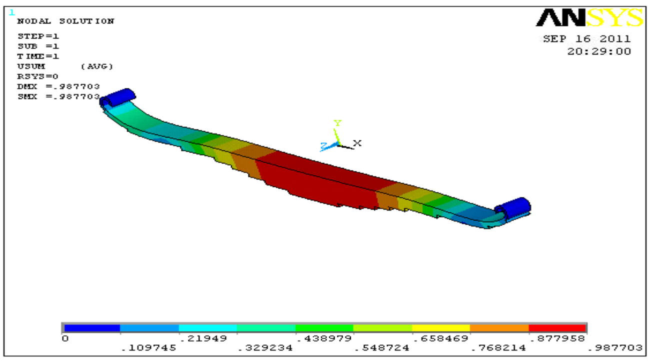

Fig.6 Distribution of Displacements plots at a load of 4000 N on steel leaf spring

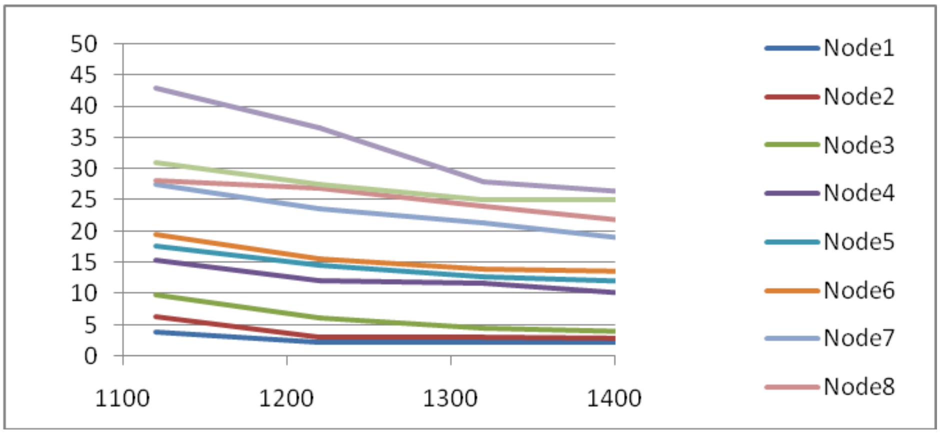

Fig.7 Comparative chart of variation of natural frequency with span

VII. CONCLUSION

The leaf spring has been modeled using solid tetrahedron 4 – node element. By performing static analysis it is concluded that the maximum safe load is 4000 N for the given specification of the leaf spring.
These static analysis results of mono composite Carbon Epoxy leaf springs are compared to steel leaf spring. The results show:

[1] The stresses in the composite leaf spring are much lower than that of the steel spring.
[2] The composite spring can designed to strengths and stiffness much closer to steel leaf spring by varying the layer
[3] config uration and fiber orientation angles.

The strength to weight ratio is higher for composite leaf spring than conventional steel spring with similar design
The major disadvantages of composite leaf spring are the matrix material has low chipping resistance when it is subjected to poor road environments which may break some fibers in the lower portion of the spring. This may result in a loss of capability to share flexural stiffness. But this depends on the condition of the road. In normal road condition, this type of problem will not be there. Composite leaf springs made of polymer matrix composites have high strength retention on ageing at severe environments.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.

REFERENCES

[1]. Machine design by S.Md.Jalaludeen, Anuradha agencies.
[2]. Machine design by R.K. Jain
[3]. Machine design by 'R.S. Kurmi'
[4]. Design of machine elements by 'Bandri'
[5]. Machine design by R.K. Rajput
[6]. Design data book by Md.jalaludeen
[7]. Design data book by P.S.G. College
[8]. www.cs.cmu.edu/People/rapidproto/mechanisms/references.html
[9]. Mechanical Engg design – Joseph E. Shigley.
[10]. Design data book – P.S.G. College of technology.
[11]. Design data book – K.Mahadevan & K.Balaveera Reddy.
[12]. Analysis and approximation of contact problem By Mircea Sofonia and Weimin Hann
[13]. Elastic contact analysis by boundary elements By Susumu Takahashi
[14]. "A comprehensive analysis of fillet and contact stresses in straight spur gears" By M.A. Alfares
[15]. www.cs.cmu.edu/People/rapidproto/mechanisms/references.html
[16]. Mechanical Engg design – Joseph E. Shigley.
[17]. Design data book – P.S.G. College of technology.
[18]. Design data book – K.Mahadevan & K.Balaveera Reddy.
[19]. Analysis and approximation of contact problem
[20]. By Mircea Sofonia and Weimin Hann
[21]. Elastic contact analysis by boundary elements
[22]. By Susumu Takahashi
[23]. "A comprehensive analysis of fillet and contact stresses in straight spur gears"By M.A. Alfares
[24]. International Journal of Computer Applications in Technology 2001 - Vol. 14, No.1/2/3 pp. 109-116