International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 5 Issue 7, July-2016

Finite Element Analysis and Weight Reduction of Leaf Spring Using CAE Tools

Amandeep[1], Ketan Mittal[2]

[1](PG Scholar, Department of Mechanical Engineering, JCDM College of Engineering, Sirsa, (Hry.), India)
[2](Assistant Professor, Department of Mechanical Engineering, JCDM College of Engineering, Sirsa, (Hry.), India)

ABSTRACT

Leaf spring is the elastic member whose function is to distort when load is applied and to regain its original shape and size when the load is removed. The most common used leaf spring for suspension in heavy and light vehicle is semi- elliptic leaf spring. The leaf spring consists of a number of leaves called blades of varying lengths. The blades have given an initial curvature so that they will tend to straighten under the load. There are mono leaf springs, or single-leaf springs, that consist of simply one plate. Today, the main aim of every automobile industry is to reduce the weight in order to safeguard natural resources and economize energy. This aim can be achieved by the introduction of better material, design optimization and better manufacturing processes. The leaf spring contributes ten to twenty percent weight to the vehicle overall weight. Design variables of conventional leaf spring consist of length of master leaf spring, width and thickness. The objective of present work is to minimize the deflection in the leaf spring and reduce the weight by changing the parameters i.e. size & shape. In the work the model of leaf spring is designed in CATIA V5 software and saved in iges format. The model is then imported in Solid Works software and saved in Para solid (x_t) format file for no data loss. This Para solid file of leaf spring is then imported in ANSYS workbench. The deformation and stress contours have been plotted and the results obtained are compared with available results in literature survey. The design optimization of leaf spring is carried out with a view to reduce weight and cost.

Keywords: ANSYS, CATIA V5, FEA, Leaf Spring

I. INTRODUCTION

A spring is defined as an elastic body, whose function is to distort when loaded and to recovers its original shape when the load is removed. 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 [1]. The Arrangement of Leaf Spring shown in Figure 1 [2].

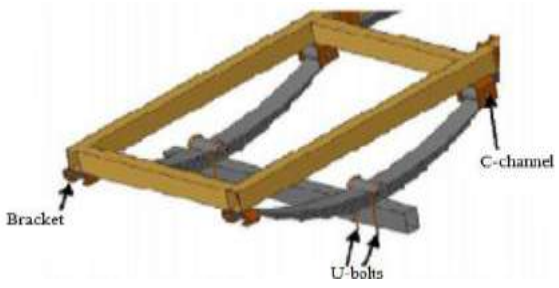

Figure 1 Arrangement of Leaf Spring

Types of Leaf Spring

1) Elliptical Leaf spring
2) Semi-Elliptical Leaf spring
3) Three Quarter elliptical Leaf spring
4) Quarter Elliptical Leaf spring
5) Transverse Leaf

A laminated semi-elliptic spring .The top leaf is known as the master leaf. The eye is provided for attaching the spring with another machine member. The amount of bend that is given to the spring from the central line, passing through the eyes, is known as camber. The camber is provided so that even at the maximum load the deflected spring should not touch the machine member to which it is attached. The camber shown in the figure is known as positive camber. The central clamp is required to hold the leaves of the spring. However, the bolt holes required to engage the bolts to clamp the leaves weaken the spring to some extent. Rebound clips help to share the load from the master leaf to the graduated leaf spring [3].

II. LITERATURE

Clarke C.K. et al. (2005) calculated the failure of leaf spring and the presence of sulphur segregation at the mid plane weakened the spring. The spring was cracked for some time in advance of the accident. The rock strike possibility was ruled out because forces adequate to rupture the spring were present well in advance of the rock strike, and wheel well marks were not consistent with short-duration forces expected from a rock strike [7].

Shankar G.S.S. et al. (2006) performed the analysis and testing of Mono Composite Leaf Spring for Light Weight Vehicle. A single leaf with unidirectional glass fiber reinforced plastic (GFRP) with similar mechanical and geometrical properties to the multileaf spring, was designed, fabricated (hand-layup technique) and tested. Computer algorithm using C-language has been used for the design of constant cross-section leaf spring. The results showed that a spring width decreases hyperbolically and thickness increases linearly from the spring eyes towards the axle seat [8].

Peerunaik M. et al. (2013) performed the static and modal analysis of leaf spring using FEA. This work was to estimate the deflection, stress and mode frequency induced in the leaf spring of an army jeep design by the ordinance factory. In analysis part the finite element of leaf spring was created using solid tetrahedron elements, appropriate boundary conditions were applied, material properties were given and loads were applied as per its design, the resultant deformation, mode frequencies and stresses were obtained and concluded that the stresses in the composite leaf spring were much lower than that of the steel spring [5].

K. Kumar et al. (2015) optimized a mono parabolic leaf spring using CAE software. In this work It was shown that the use of composite material instead of steel resulted into large deflection, small variation in stresses and also a large amount of weight reduction [4].

III. METHODOLOGY

Prepare Model: The first step is to prepare a CAD model of master leaf spring. The model of leaf spring is designed in CATIA V5 software and saved in iges format. The geometrical specification of leaf spring is given in table 1[4].

Table 1 Specification of Leaf Spring

Span Length	940 mm
Number of Leaf	1
Rated Load	1800 N
Width of Leaf	60 mm
Centre Rubber Pad	100 mm X 50 mm X 5mm

The model of leaf spring is then imported in Solid Works software and saved in Para solid (x_t) format file for no data loss. This Para solid file of leaf spring is then imported in ANSYS workbench. In the present work, material is removed from the bottom of leaf spring up to thickness 1 mm as shown in Figure 2. The deformation and stress contours have find out using ANSYS workbench. The results obtained are compared with available results in literature survey.

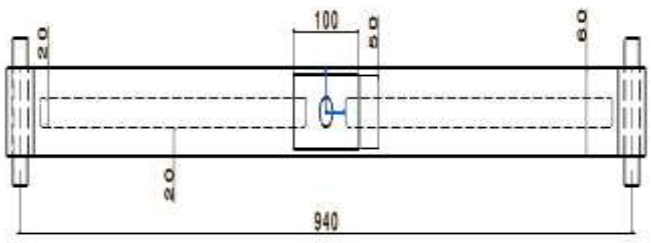

Figure 2 Leaf Spring Drawing after Modification

The Fig 3 shows the CAD model of leaf spring in CATIA V5 Software.

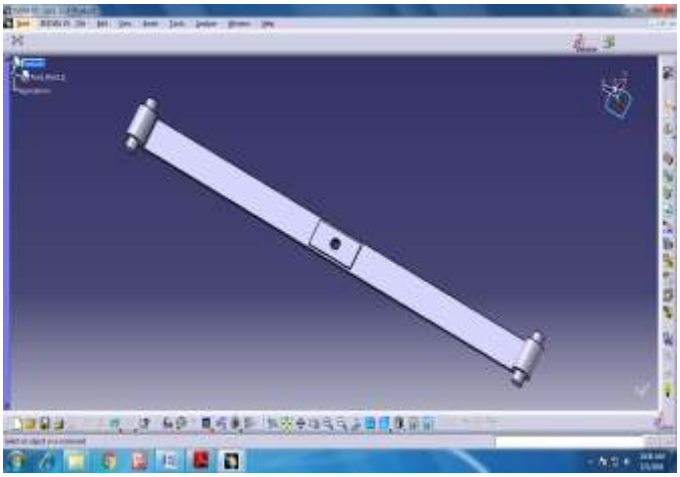

Figure 3 CAD model of leaf spring

Mesh generation

Second step is to generate mesh using parabolic tetrahedral elements. An automatic method is used to generate the mesh in the present work. Fig 4 shows the meshed model of leaf spring in AYSYS workbench.

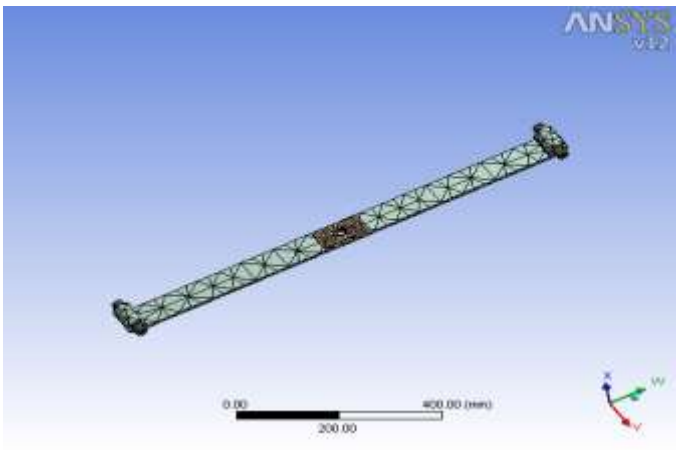

Figure 4 Meshed model of Leaf Spring in ANSYS workbench

Boundary Conditions:

Third step is to apply boundary conditions. The boundary condition is the collection of different forces, supports, constraints and any other condition required for complete analysis. Applying boundary condition is one of the most typical processes of analysis. A special care is required while assigning loads and constraints to the elements. Boundary condition of the leaf spring involves the fixation of one of the revolute joint and applying displacement support at the other eye end of leaf spring. A joint rotation of 2.2° has been taken for both revolute joints considering the no load camber. Loading conditions involves applying a load of 1500 N at the centre of the leaf. As per specifications the spring is drawn at flat condition, therefore the load is applied in downward direction to achieve initial no load condition. The model under defined boundary conditions is shown in Fig 5[4].

Model Display

While applying the boundary conditions, it is necessary to view the model from different angles Pre-Processor offers capabilities of rotating, smoothness, scaling, regions, active set, etc. for efficient model viewing and editing.

Solution

The Solution phase deals with the solution of the problem according to the problem definitions. All the tedious type of work of formulating assembling of matrices is done by the computer and finally displacements and stress values are given as output.

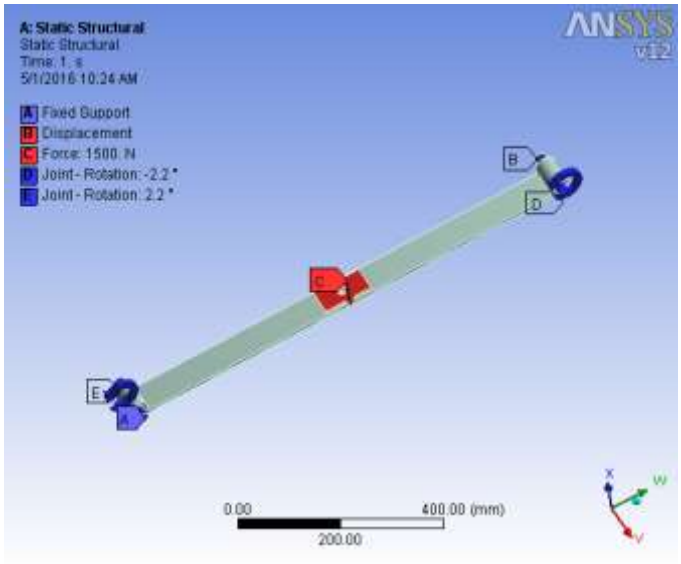

Figure 5 Applied constraints on the Leaf Spring

Post- Processor

It is a powerful user friendly Post-Processing program using interactive colour graphics. It has extensive plotting features for displaying the results obtained from the Finite Element Analysis. One picture of the analysis results (i.e. the results in a visual form) can often reveal in seconds what would take an engineer hour to assess from a numerical output, say in tabular form. The engineer may also see the important aspects of the results that could be easily missed in a stack of numerical data. The entire range of Post-Processing options of different types of analysis can be accessed through the command/menu mode there by giving the user added flexibility convenience Employing state of art image enhancement techniques facilitates the viewing of:

- Contours of stresses, displacements, temperatures etc,
- Deform geometric plots, light source shaded plot,
- Animated deformed shapes,
- Time-history plots,
- Solid sectioning hidden line plot and boundary line plot etc.

IV. STATIC STRUCTURAL ANALYSIS

Static structural analysis is done in ANSYS workbench to find out the equivalent (von-mises) stress and total deformation. Fig. 6 and Fig. 7 show equivalent (von-mises) stress and total deformation in the leaf spring.

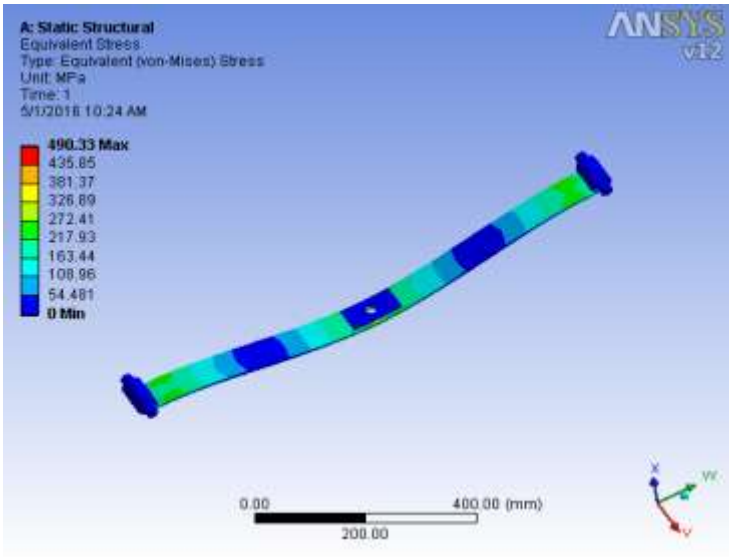

Figure 6 Equivalent (von-mises) stress

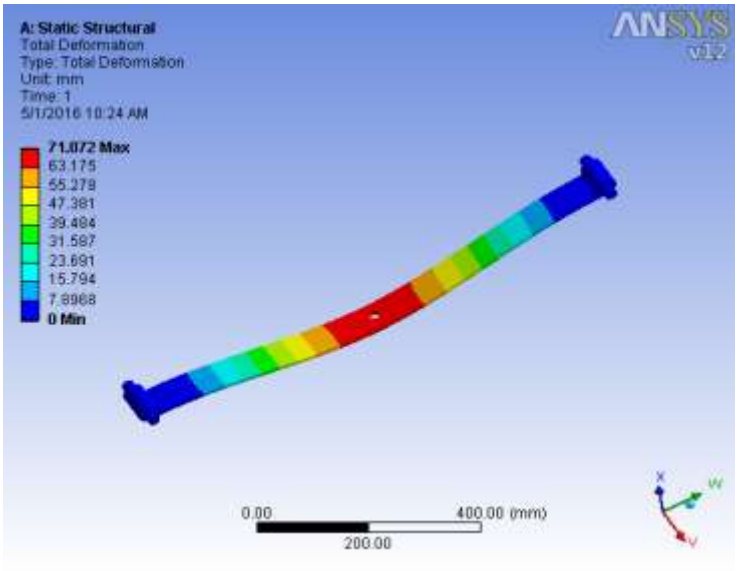

Figure 7 Total Deformation

Table 2 FEA results of Leaf Spring

Sr. No.	Parameters	Existing Design	Proposed Design
1.	Normal Static Load	1500 N	1500 N
2.	Equivalent (von-mises) stress	501.26 MPa	490.33 MPa
3.	Total deformation in mm	71.724 mm	71.072 mm
4.	Total Weight	1.3716 kg	1.2039 kg

From the above comparison Table 2 it has been observed that for the same static load and boundary conditions, the , the deflection in the case of existing leaf is 71.724 mm while in case of proposed leaf it is 71.072 mm which shows that proposed leaf has a little bit less deflection in comparison to existing one. Also the value of von-mises stress has been decreased from the 501.26 MPa to 490.33 MPa. At the same time a weight also reduces from the 1.3716 kg to 1.2039 kg.

CONCLUSION

Finite Element Analysis of the leaf spring has been done using ANSYS Workbench. From the results obtained from FE Analysis, many discussions have been made. The results obtained are well in agreement with the available existing results. The model presented here, is well safe and under permissible limit of stresses.

1. On the basis of the current work, it is concluded that the proposed material give sufficient improvement in the existing results.
2. The weight of the leaf spring is also reduced by 12.22 %, thereby reducing the cost.
3. The stress is found maximum near the hole and sharp edges.

REFERENCES

[1]. B.Mahesh Babu , D.Muralidhar Yadav, N.Ramanaiah "Leaf Spring Analysis with Eyes Using FEA" ISSN: 2250-3005 ,IJCER Vol 03, Issue 10, October 2013.
[2]. Trivedi Achyut V. , Prof. R.M. Bhoraniya "Static and Dynamic Analysis of Automobile Leaf Spring (TATA ACE)" ISSN (online): 2349-784X , IJSTE, Volume 1 , Issue 11 , May 2015.
[3]. Pradeep B. Tapkir , Prof. Balaji Nelge "Fatigue Life Prediction Of Composite Semi-Elliptical Leaf Spring For Heavy Vehicle" ISSN: 2277-9655, IJESRT, 4.(6), June, 2015.

[4]. Krishan Kumar and M. L. Aggarwal "Finite element analysis and optimization of a mono parabolic leaf spring using CAE software" Engineering Solid Mechanics, 3, (2015).
[5]. Meghavath. Peerunaik, Tippa Bhimasankara Rao , K.N.D.Malleswara Rao "Static and Modal Analysis of Leaf Spring using FEA" IJCER, Vol, 03, Issue, 4, April 2013.
[6]. Manjunath H.N, Manjunath.K, T.Rangaswamy "Static Analysis and Fatigue Life prediction of Composite Leaf Spring for a Light Commercial Vehicle (TATA ACE)" ISSN:2319-6890, IJER, Volume No.3, Issue No.7, 01 July 2014.
[7]. C.K. Clarke and G.E. Borowski "Evaluation of a Leaf Spring Failure" Journal of Failure Analysis and Prevention, Volume 5(6) ,December 2005.
[8]. Gulur Siddaramanna Shiva Shankar, Sambagam Vijayarangan "Mono Composite Leaf Spring for Light Weight Vehicle – Design, End Joint Analysis and Testing" ISSN 1392–1320, Materials Science (Medžiagotyra), Vol. 12, No. 3. ,2006.