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Structural Analysis of Leaf Spring of Light Weight Commercial Vehicle Suspension System

Sunil Chaurasia [*1], Anil Elisala [2], Gvr Seshagiri rao [3], Vipul Jain [4]

[*1] Research Scholar, Department of mechanical engineering, BM College of Technology, Gokanya, Khandawa Road, Indore, Madhya Pradesh, India

[2] Associate Professor, Department of mechanical engineering, BM College of Technology, Gokanya, Khandawa Road, Indore, Madhya Pradesh, India

[3] Associate Professor and Department Head, Department of mechanical engineering, BM College of Technology, Gokanya, Khandawa Road, Indore, Madhya Pradesh, India

[4] Assistant Professor, Department of Mechanical Engineering, Shri Vaishnav Institute of Technology and Science, Gram Baroli, Sanwer Road, Indore, Madhya Pradesh, India

getsunilchaurasia@gmail.com

Abstract

Mathematical and computer modeling have been playing an increasingly important role in the computer aided engineering (CAE) process of many products since last 60 years. The present work consists of a leaf spring involving two supporting leafs with the main Leaf. Main leaf and the centre leaf are having a uniform cross section throughout the length of the blade, while the bottom leaf having a thickness of around 1.5 times of that of the other two. Moreover a central bolt and two supporting U-Bolts are provided to hold leafs together. The load is applied axially downwards at the eye ends of the main leaf and a double magnitude load is applied at the bottom of the bolt. Here in the present model we have taken the steel material for the analysis purpose and the nut is firmly fixed by giving a fully constrained boundary condition on it. An octree 10 node modified tetrahedron mesh element is used for the discretization of the spring model. For the whole work i.e., from the modeling to the result generation CATIA V5R12 software is used and the obtained results are finally compared with the numerically obtained result of stress and deflection to validate the simulation results. Vehicle whose, leaf spring dimension are taken is light commercial vehicle (Ashok Leland Dost).

Keywords: CAE, Leaf Spring, CATIA, Load, Deformation.

Introductions

The suspension system of an automobile is one which separates the wheel/axle assembly from the body. The primary function of the suspension system is to isolate the vehicle structure from shocks and vibration due to irregularities of the road surface. [1]

Leaf springs are mainly used in suspension systems to absorb shock loads in automobiles like light motor vehicles, heavy duty trucks and in rail systems. It carries lateral loads, brake torque, driving torque in addition to shock absorbing. [2]

The evolution of computer aided engineering (CAE) Methodology has playing a major role in the advancement of traditional structural engineering. It has allowed engineering to obtain better solution for design and analysis problem by means of diverse user friendly software package. However, as the precision and safety requirements have increased in the every changing world, civil and structural engineering face numberless unsolved issues with respect to structural optimization and control. [3]

The primary purpose of this project is to increase the load caring capacity and life expectancy by changing the existing parabolic two stage leaf spring of light commercial vehicle.

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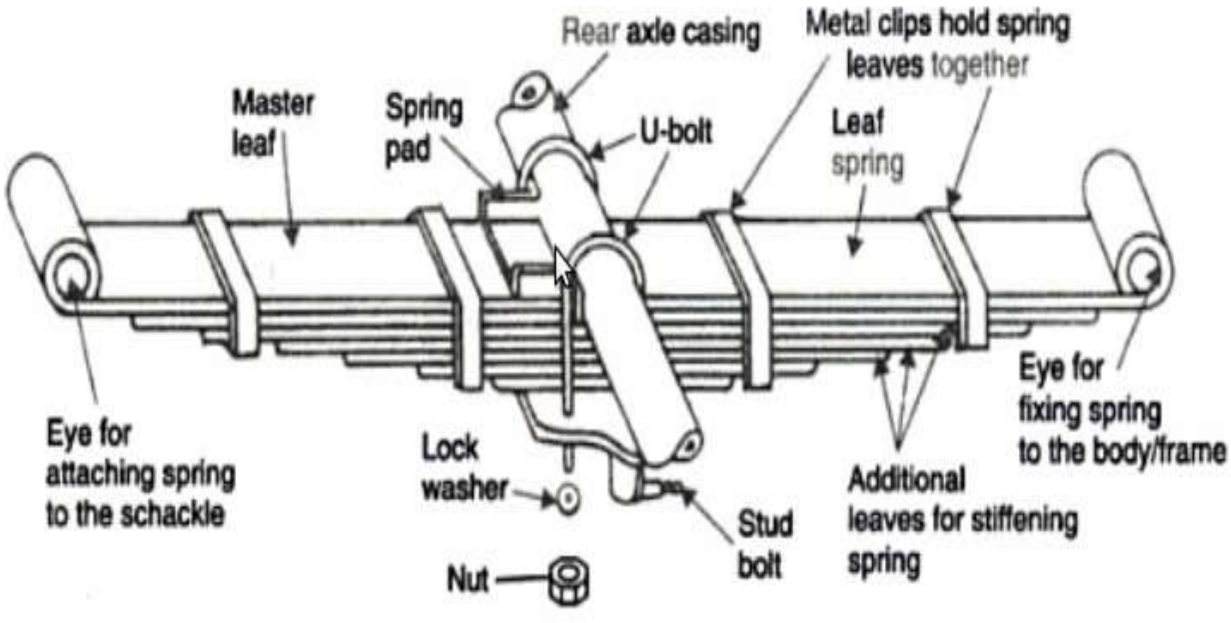

Figure 1: Nomenclature of leaf spring

Literature review

Leaf springs are one of the oldest suspension components they are still frequently used, especially in commercial vehicles. The automobile industries have shown interests in replacement of steel springs with composite leaf springs due to high strength to weight ratio. [4] Multi leaf spring carries lateral loads, brake torque, driving torque in addition to shock absorbing. It is well known that springs, are designed to absorb and store energy and then release it slowly. Ability to store and absorb more amount of strain energy ensures the comfortable suspension system. [5] Conventional 65si7 spring steel leaf spring model with standard eye end and casted eye end are considered. The CAD model of the leaf springs is prepared in CATIA and analyzed using ANSYS. [6] The FE analysis of the leaf spring has been performed by discretization of the model in infinite nodes and elements and refining them under defined boundary condition. Bending stress and deflection are the target results. A comparison of both i.e. experimental and FEA results have been done to conclude. [7]

Methodology

The deflection of leaf spring is obtained numerically by the formula:

$$\delta = \frac{12W.L^3}{E.b.t^3(2n_G + 3n_F)}$$

$$\sigma = \frac{6WL}{nbt^2}$$

Where:
δ = Deflection of the spring in mm
σ = Stress in N/m^2
W = Central load in Newtons
n = Number of Leaves
n_F = Number of Leaves of full length
n_G = Number of graduated leaves
E = Young's Modulus of Elasticity in N/m^2
b = Width of the leaves in mm
t = Thickness of the leaves in mm

The Simulation process of leaf spring can be understood by the following flow chart:

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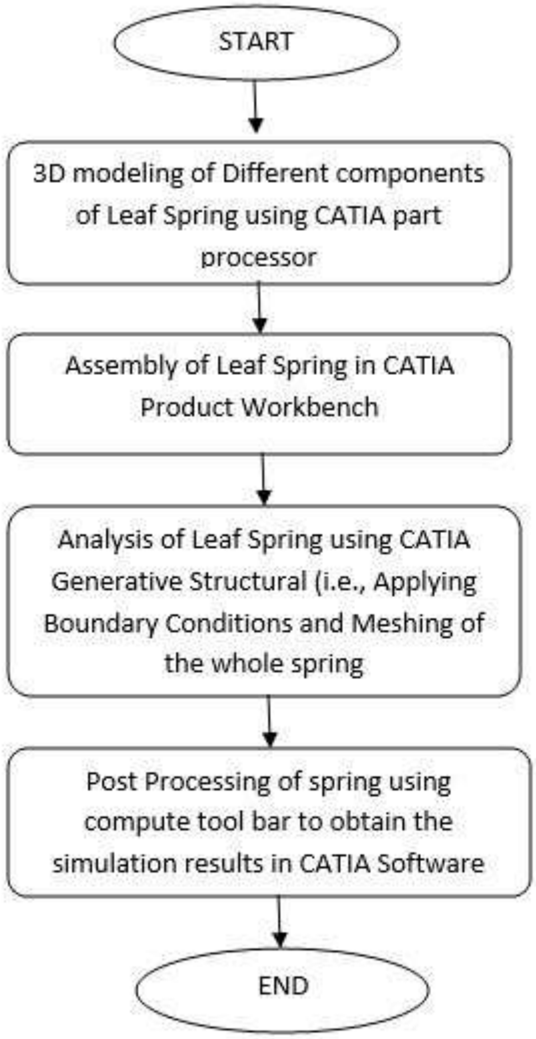

Figure 2: Flow chart

Following are the material properties which are taken for the present analysis:

Table.1: Material Properties for Analysi

MATERIAL PROPERTIES		
S.NO.	PROPERTY	VALUE
1	Elasticity Modulus	$2x10^{11}$ N/m^2
2	Poisons Ratio	0.266
3	Density	7860 Kg/m^2
4	Thermal Expansion	0.0000117
5	Yield Strength	$2.5x10^8$ N/m^2

Figure 2 shows the flow chart of the whole steps which are followed for the computer aided analysis of leaf spring. Figure 3 shows the model of leaf spring. Figure 4 shows the meshing and boundary conditions as applied to the leaf spring. Figure 5 shows the deformed shape of leaf spring with the minimum to maximum value of displacement throughout the spring similarly, Figure 6 shows the stress distribution value for the leaf spring.

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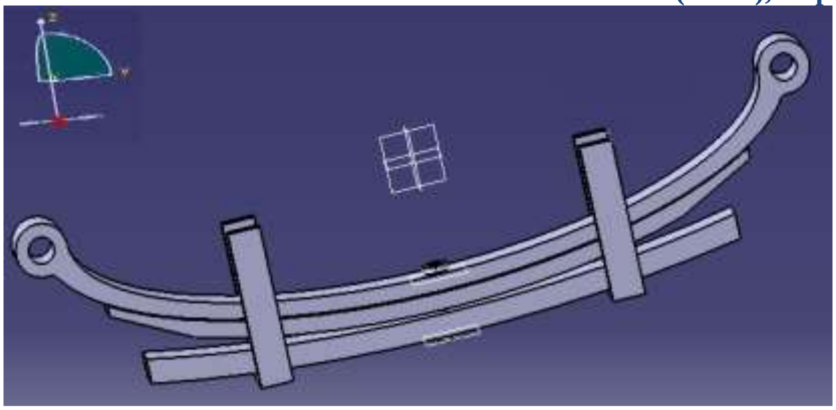

Figure 3: Model of leaf spring

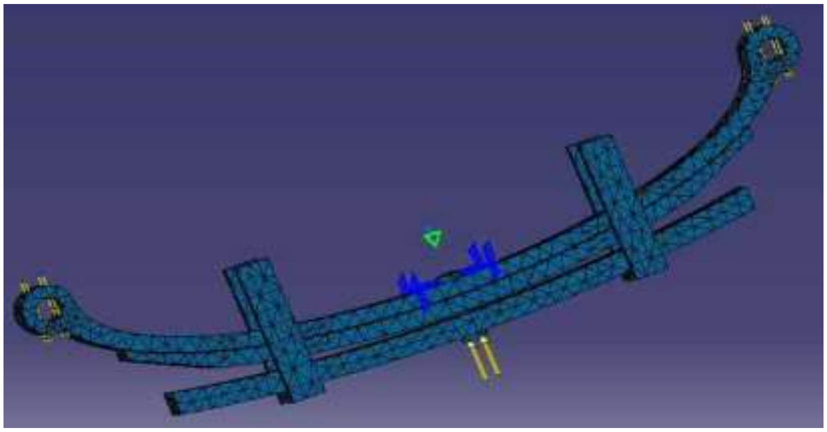

Figure 4 : Meshing and Boundary Conditions

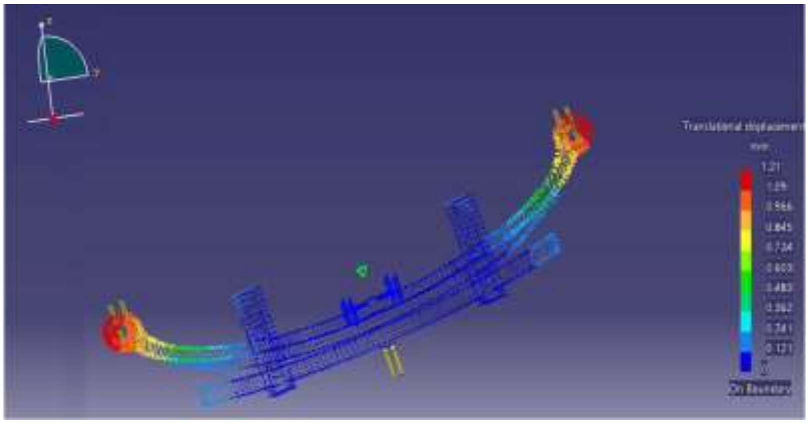

Figure 5: Deformed shape of Leaf Spring

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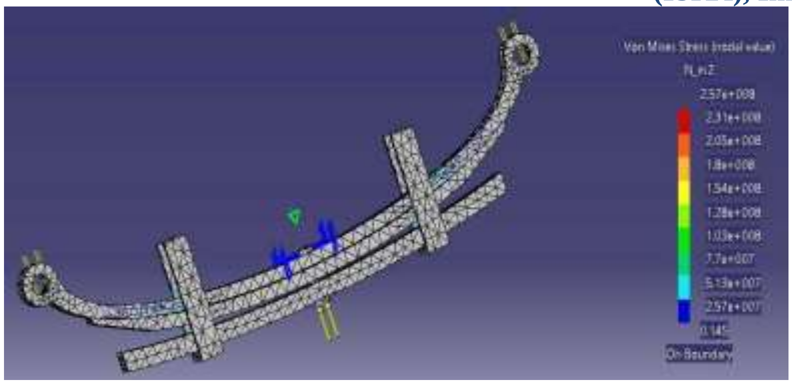

Figure 6 : Induced Stresses of Leaf Spring

Results and discussions

1. The Maximum Axial Deflection is found to be 1.2 mm which is slightly greater then theoretically obtained result.
2. The maximum von-misses Stress varies from $2.57x10^7$ N/m^2 to $2.57x10^8$ N/m^2 which quite greater then the theoretically obtained stress i.e., $5.67x10^7$ N/m^2
3. The best mesh size for the present analysis is found to be 13 for the best results with the octree 10 node tetrahedral (quadratic) element.

Conclusion

1. This method provides the predication of critical area from view point of static loading. This will help us to selection of right cross section and property of material at that area. So that the failure of spring could be predicted.
2. It is concluded that the CAE tools provide a cost effective and less time consuming solution then the complex time consuming numerical solutions.

Future scope

1. Experimental setup may be conducted to compare results from simulation and theoretical results to obtain more precise results.
2. A composite material may be used to enhance the effectiveness of the spring.
3. The analysis may be conducted in different FEA analysis software to get better results to that of theoretical one.
4. The spring can be modeled with different dimensions such as changing leave thicknesses, width of spring and so on and respectively the load on spring can be changed.
5. A dynamic analysis may be performed and the experimental and simulation results can be compared for that too.

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