Static Analysis And Modification Of Multi – Leaf Spring Using Catia V5

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Abstract **- The objective of this contemporary work is to evaluate the deflection and stress induced in the leaf spring of a light vehicle carrying static load of 6685N. The emphasis in this project is on the application of computer aided analysis using finite element concept. The component chosen for analysis is an elliptical leaf spring which is an self-propelled component used to engross vibrations prompted during the motion of vehicle. It also turns as a structure to upkeep vertical loading due to the weight of the vehicle and payload. Under operating conditions, the performance of the elliptical leaf spring becomes difficult due to its clamping effects and interleaf contact, hence its analysis is vital to forecast the displacement and stresses. The leaf spring, which we are analyzing, is a custom designed leaf spring used by Mahindra after analyzing this predesigned model some modifications are made in the modal and changed model is again analyzed and worked to get better results. This spring is intended to bear heavy jerks and vibrations reduced during real operating conditions. In analysis part the finite element of elliptical leaf spring is modeled using CATIA V5. Appropriate boundary conditions, material properties and loads are applied selected as per intended performance. The resultant deformation and stresses obtained are analyzed.**

Keywords—Leaf Springs; Elliptical leaf springs;Simulation of Leaf spring; Static analysisof Leaf Spring in CATIA V5

1. INTRODUCTION

Multi-leaf springs are commonly used for automobile and rail road suspension. They are made up of series of plane plates, usually of semi - elliptical profile. The leaves are held together by the use of two U-bolts and a centre clip. Retreat clips are provided to maintain the leaves in position and avoid tangential variation of the plates during the course of action. The longest leaf, called the master leaf, is perverted at both ends to form the spring eye. At the center, the spring is set to the axle of the vehicle. Multi- leaf springs are provided with one or two supplementary full length leaves in addition to the master leaf. These supplementary full-length leaves are positioned between the master leaf and the graduated-length leaves. The additional full-length leaves are provided to support the transverse shear force. A modern execution is the parabolic leaf spring. This design is characterized by fewer leaves whose thickness varies from centre to ends following a parabolic curve. In this design, inter-leaf friction is surplus, and therefore there is only contact among the springs at the ends and at the centre where the axle is connected. Spacers prevent contact at other points. Aside from weight saving, the main advantage of parabolic springs is their better 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 in 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.

2. CAE TOOLS, CAD METHODOLOGY AND FINITE ELEMENT MODELING

Computer-aided technologies are broad terms describing the use of computer technology to aid in the design, analysis, and manufacturing of products. Computer aided engineering embraces the application of computers from preliminary design (CAD) through production (CAM). Computer Aided Analysis includes finite element and finite difference method for solving the partial differential equations governing solid mechanics, fluid mechanics etc. Computer aided manufacturing (CAM) includes programs for generating the instructions for computer numerically controlled (CNC) machining to production and process scheduling and inventory control.

2.1. Cae And Process Management

The various activities that make up Computer aided engineering are an essential part of the product design cycle to speed up the design cycle, to ensure that the products designed are of higher quality, and to reduce cost of the final product. Broadly, the tasks the designer has to carry out, exists in two categories the first is model creation, while the second covers reporting and interpretation of results. The potential impact of CAE errors can be very high.

2.2. Computer Aided Analysis (Caa)

Computer aided analysis is a technique by which approximate solution of a numerical problem is carried out. Computer aided analysis includes finite element analysis for solving the partial differential equations governing solid mechanics, fluid mechanics, and heat transfer, diverse programs for specialized analysis such as rigid body dynamics and control system modeling.

3. CATIA

CATIA (Computer Aided Three Dimensional Interactive Application) is multi- platform CAD/CAM/CAE commercial software, written in the C++ programming language. CATIA is the cornerstone of the Dassault systems.

3.1. Features and capabilities

Commonly referred to as 3D Product Lifecycle Management software suite, CATIA support multiple stages of product development. The stages range from conceptualization through design (CAD) and manufacturing (CAM), until analyses (CAE). CATIA is very good in surface creation and computer representation of surfaces. Its capabilities are applicable to a variety of industries such as aerospace, automotive industrial machinery, electrical, electronics, shipbuilding, plant design, and consumer goods.

3.2. Simulation Environment

This drop-down list is used to specify whether you want to perform:

Static analysis

Frequency analysis

4. FINITE ELEMENT MODELING

The finite element method is a numerical method for solving engineering and mathematical physics problems. The typical use of this method is to solve the problems in the field of stress analysis, heat transfer, fluid flow, mass transfer and electromagnetic. This method is able to solve physical problems involving complicated geometrics, loadings and material properties which cannot be solved by analytical method. In this method, the domain in which the analysis to be carried out is divided into smaller bodies or unit called as finite elements. The properties of each type of finite element is obtained and assembled together and solved as whole to get solution. Based on application, the problems are classified into structural and non-structural problems. Finite Element Analysis, development of structures must be based on hand calculations only. For complex structures, the simplifying assumptions required to make any calculations possible can lead to a conservative and heavy design. A considerable factor of ignorance can remain as to whether the structure will be adequate for all design loads. In structural problems, displacement at each nodal point is obtained. Using these displacement solutions, stress and strain in each element are determined. Using these nodal values, properties like heat flux, fluid flow etc., for each element is determined. Since large computations are to be carried out, this method requires high-speed computation facility with large memory. Finite element method and Finite element analysis are both one and same term. But term FEA is more popular in industries while FEM is famous at universities.

5. PROPOSED WORK

The first step is to prepare a CAD Model of elliptical leaf spring in CATIA V-5. In the present work results have compared for two changed dimensions of structural steel model. CAD modeling of the leaf spring has been generated using CATIA V-5 software. Then the model is edited for weight saving and better performance.

5.1. **Comparison table for design data**

Specifications		
	Original Modal	Edited Model
Total length of spring	1120	1120
No. of full length leaves	2	2
No. of graduated leaves	8	8
Thickness of leaves	6 mm	6.5 mm
Width of leaf spring	50 mm	40 mm
Maximum load on spring	6685 N	6685 N
FOS	1.4	1.4

Table-1 Specifications

5.2. Design parameters of leaf spring

Leaf Number	**Full Leaf Length (mm)**	**Radius of curvature (mm) for original modal**	**Radius of curvature (mm) for edited modal**
1	1120	961.11	961.11
2	1120	967.11	967.61
3	1007	973.11	974.11
4	894	979.11	980.61
5	780	985.11	987.11
6	667	991.11	993.61
7	554	997.11	1000.11
8	440	1003.11	1006.61
9	327	1009.11	1013.11
10	214	1015.11	1019.61

Table-2 Design Parameters of steel Leaf spring

Here is the Drawing of the model in CATIA V5.

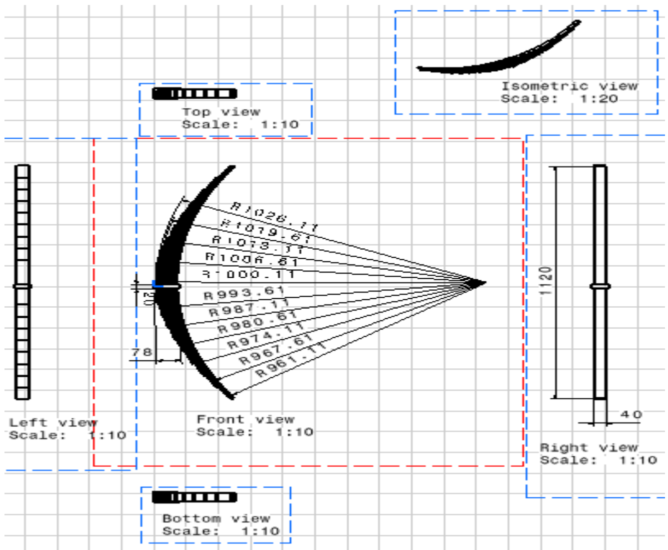

Figure-1 drawing of leaf spring of model

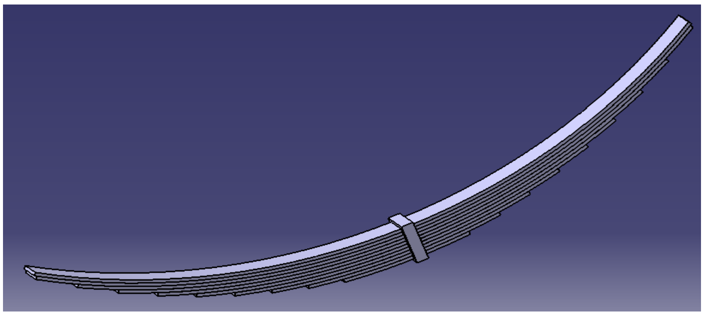

Figure-2 model of leaf spring

Model is saved in the CATAssembly format. Finally the model imported in Generative structure analysis Workbench for further analysis. Static Analysis is done on the model.

6. MATERIAL PROPERTIES OF MATERIAL OF LEAF SPRING

Property	Structural steel
Young's Modulus,(E)	$2*10^5$ MPa
Poisson's Ratio	0.266
Tensile Yield strength	250 MPa
Compressive yield strength	250 MPa
Density	7850 kg/m^3
Behavior	Isotropic

Table-3 Material properties of structural steel for Leaf Spring

7. MESH GENERATION

An automatic method has been used to generate the mesh in the present work.

Original Model
Nodes- 5712
Elements- 1961
Edited Model
Nodes- 5626
Elements- 1827

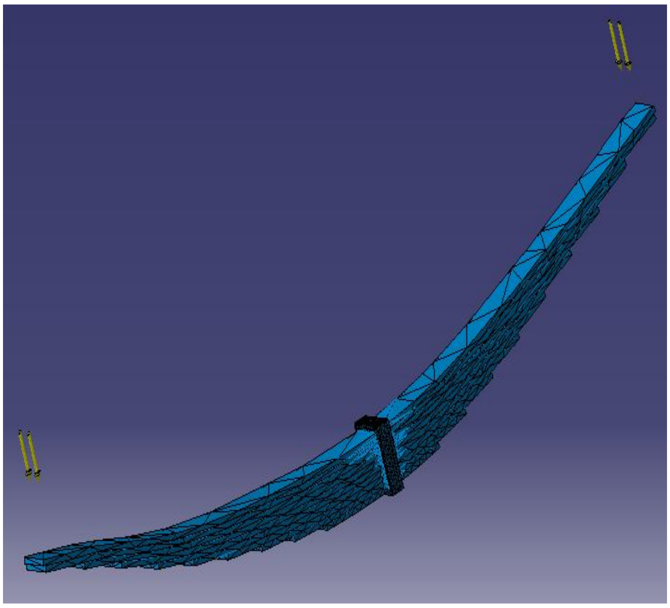

Figure-3 Meshed model of leaf spring

8. BOUNDARY CONDITIONS

After completion of the finite element model, boundary conditions and loads are applied. The boundary conditions are the collection of different forces, supports, constraints and any other condition required for complete analysis. Applying boundary conditions is one of the most typical processes of analysis. A special care is required while assigning loads and constraints to the elements. Two displacements & Loads of 6685N are applied.

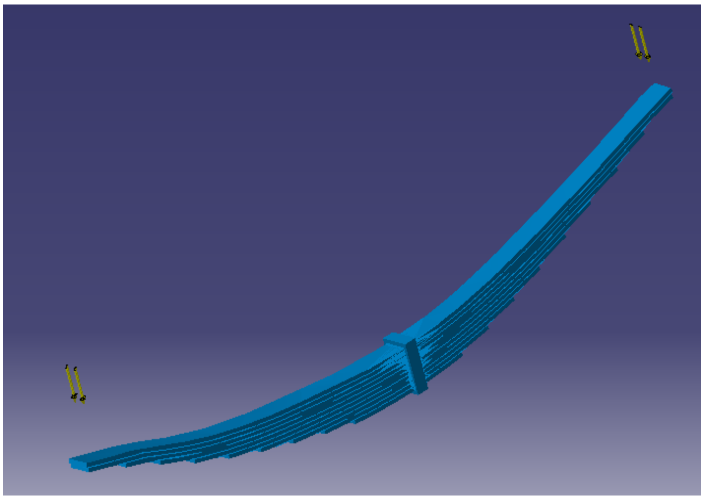

Figure-4 Applied displacement supports and loads on edited leaf spring

8.1. Model Display

While applying the boundary conditions, the model is viewed from different angles. Pre processor offers capabilities of rotating, smoothness, scaling, and regions etc. for efficient model viewing and editing.

8.2. Solution

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

9. RESULTS AND DISCUSSIONS

9.1. Static Analysis

Figures below shows the equivalent (Von-Mises) stress, maximum principal stress, total deformation, in the leaf spring for a 6685N load. The color shown in the leaf spring represents the stress and deformation present in the element. Red color shows the maximum stress & maximum deformation, whereas, blue color shows the minimum stress and minimum deformation in the respective figures. Fig. 5.1 shows the equivalent (Von-Mises) stress of the leaf spring for a load of 6685N. The maximum(Von-Mises) stress is found to be 10.4 MPa which is at near the fixed support as shown by red color, this includes local stress. Excluding local stress its value is 9.4 MPa. Figures 5.4, and 5.6 show maximum principal stress value 8.4 MPa , minimum principle stress value -7.8 MPa and maximum displacement value 0.01mm and minimum displacement value is 0 also the volume of the material used is less in edited model as compared to the original model.

Therefore better results are obtained with reduced weight of elliptical leaf spring. Here about per cent weight is reduced in edited model as compared to the original model.

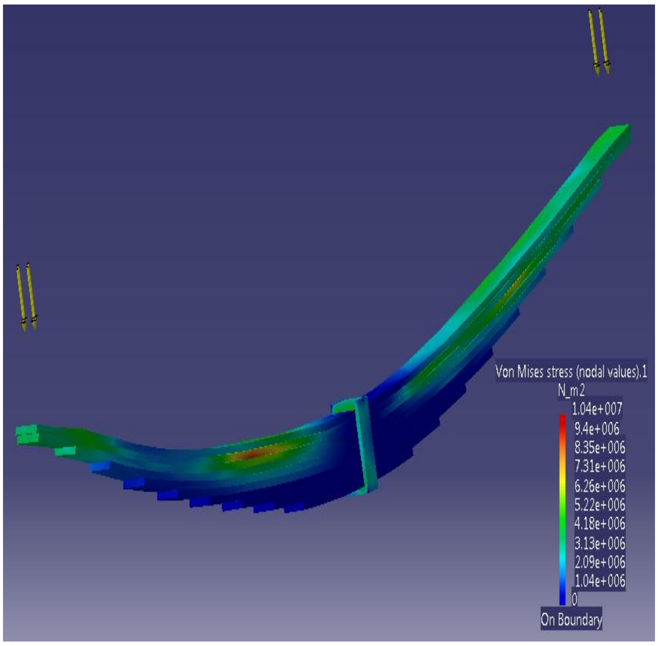

Figure-5 Equivalent (Von-Mises) stress for each element in the leaf spring

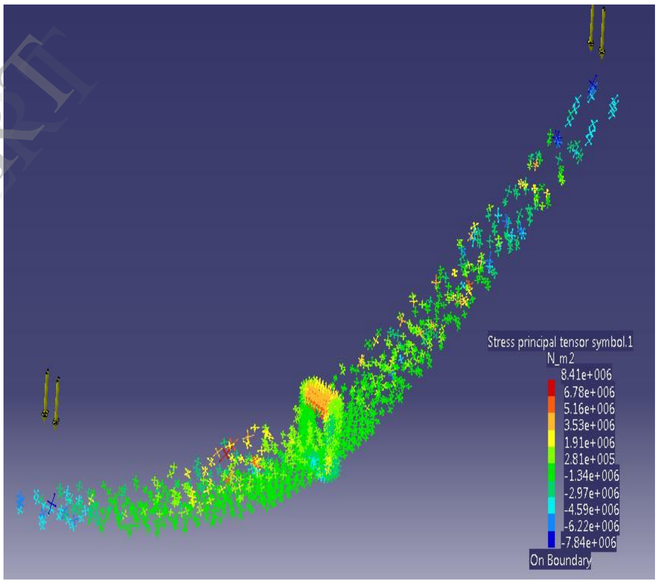

Figure-5 Maximum Principal stresses for each element in the leaf spring

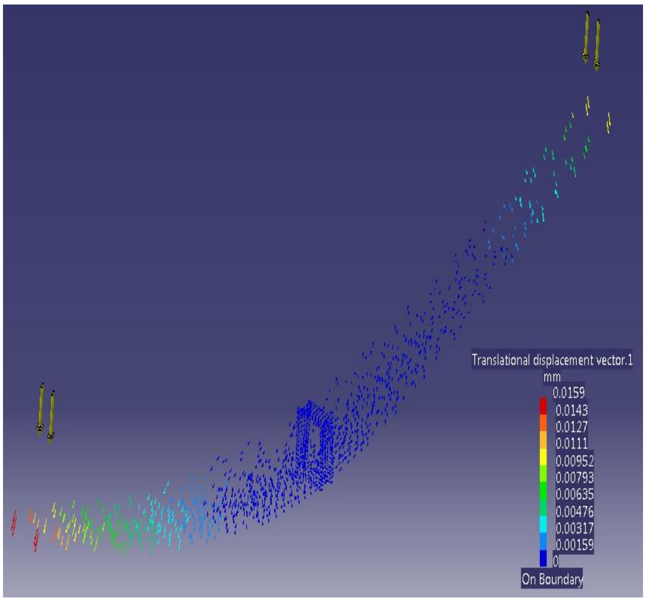

Figure-5 Maximum Displacement for each element in leaf spring

10. COMPARISON OF RESULTS OF TWO MODELS FROM SOFTWARE

S NO.	Property	Original Model	Edited Model
1	Von-Mises stress	21.1 MPa	10.4 MPa
2	Maximum principle stress	15.7 MPa	8.4 MPa
3	Minimum principle stress	-13.9 MPa	-7.8 MPa
4	Maximum static displacement	0.141 mm	0.0159 mm

Table-4 Results Comparison static analysis

11. CONCLUSION

The maximum Von–Mises stress (including local stress and global stresses) in structural steel material is 21.1 MPa in original modal and 10.4 MPa in edited modal. These values are less in edited modal in original modal. The models presented here are safe and under permissible limit of stresses.

The maximum Von–Mises stress (including local stress and global stresses) in structural steel material is 91.1 MPa in original modal and 80.8 MPa in edited modal. These values are less in edited modal in original modal. The models presented here are safe and under permissible limit of stresses.

The springs are both safe for working at speed of free vibration up to 280 Hz, which can never be seen in any leaf spring under working condition. Therefore the spring is safe.

Depending on volume the weight of steel reduction is seen here.

The results obtained are well in agreement with the required results.

Leaf springs with more thickness and less width are safer as compared to the leaf spring with less thickness and more width.

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