Linear Static and Normal Mode Analysis of 16 Ton Truck Capacity of Multi Leaf Spring under the Dynamic Load Condition using FEA

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Abstract - The research addresses certain special concept of multi leaf steel spring used in the rear suspension system of heavy vehicle truck of 16 Ton capacity are designed, analysed with the help of CAD and CAE Technology. The design of leaf spring is generated on CATIA V5R21 CAD software. The next step is the Finite Element modeling of leaf spring in Hypermesh pre-processor. By FE modeling, hexahedron 2nd order element solid meshing will performed and the material as well as thickness properties will assign simultaneously in HYPERMESH 14.0 for FEA validation. After completing the meshing of leaf spring with high accuracy quality criteria's providing results with zero error would be analyse in Linear Static and Normal Mode analysis on MSC Patran pre-post processor 12.1 and MSC Nastran Solver 12.1 with the help of CAE virtual simulation. In case of Linear static analysis SOL 101 and in normal mode analysis SOL 103 parameters would be used on MSC Patran for getting the accurate deflection and mode shapes results. In leaf springs, the Linear static analysis and Normal mode analysis has been done by applying the 16 Ton load. During the analysis various calculations has been performed by the Nastran Solver. In addition, to the finite element analysis results it will show stresses, deflections and natural frequency which will be verified with the analytical and numerical solutions by hand calculations.

Keywords: Leaf Spring, Simulation, Static, Normal mode.

I. INTRODUCTION

In this section leaf spring is considered as the simple type of spring, normally used for the suspension in vehicles. Leaf springs are generally used in suspension system to absorb shock load such as in automotive light vehicles, heavy duty vehicles and in rail systems. The multiple leaves of leaf spring often start with gradually shorter leaves to provide ease in riding very heavy vehicles. The key characteristic that gives smoothness to a vehicle is its suspension. In this research paper we will give brief details of Linear static analysis, Normal mode analysis. The multi-leaf spring is made of 10 steel plates of different lengths stacked together. During normal operation, the spring compresses to absorb road shock. The leaf springs bend and slide on each other allowing suspension movement.

II. MODELING ON LEAF SPRING

In this section the model is generated on CATIA V5 R21 and FE modeling is done on HYPERMESH 14.0 with different specifications in leaf spring. The research paper provides various resource images or diagram. It will include linear static images as well as in normal mode analysis images to getting CAE virtual simulation results. This simulation shows various results in linear static and normal mode analysis. The finite element analysis helps to apply the 16 Ton capacity load on truck. The load provides deflection, von mises stress and normal mode frequency with the help of simulation process.

S.No	Parameters	Value
1.	Total length of the spring (Eye to Eye)	1047.718 mm
2.	Free camber (At no load condition)	40 mm
3.	Number of full length leave (Master leaf)	01
4.	Thickness of leaf	20 mm
5.	Width of leaf spring	40 mm
6.	Maximum load given on spring	15690 N
7.	Young's Modulus of leaf spring	7.8e5 N/mm2

Figure 2.1: Specification of Leaf Spring [1]

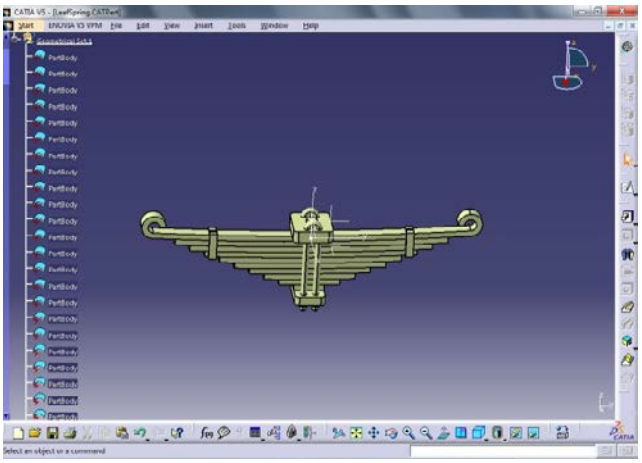


Figure 2.2: Leaf Spring model generation in CATIA [2]

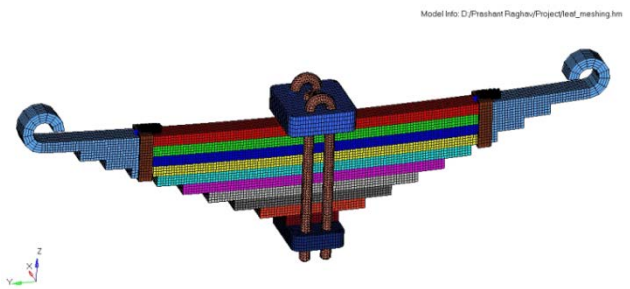


Figure 2.3 FE Modeling on Leaf Spring [3]

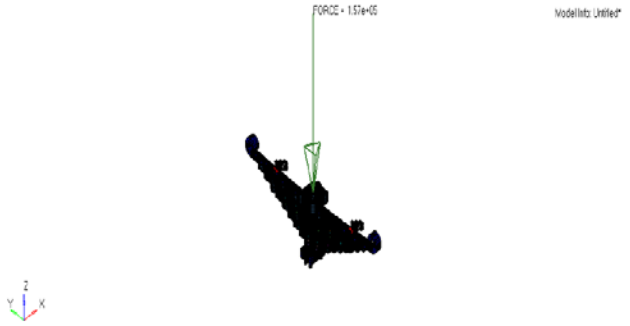


Figure 2.4: 16 Ton Load apply on Leaf Spring

The forces apply on leaf spring is of 16 Ton which is apply on middle of the camber. The load is uniformly distributed to all parts of leaf spring. The 16 ton load is converted into Newton by doing calculation i.e. 16000 × 9.81 N. Hence, this will be showing the exact forces apply on leaf spring is 1.57e+05 N.

Force, F = Mass × Acceleration due to gravity

$$F = m \times g$$

$$F = 16000 \times 9.81$$

Force, F = 1,56,960 N

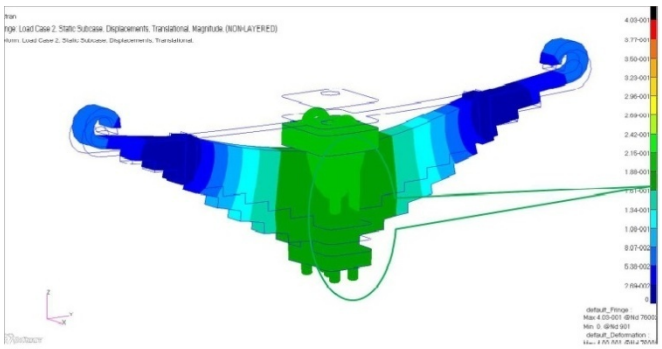


Figure 2.5 Deflection of Leaf Spring

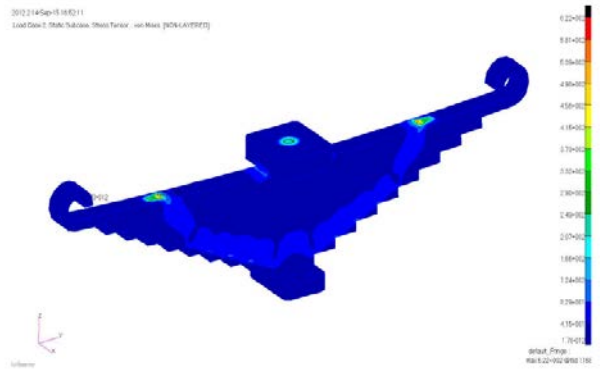


Figure 2.6 Von Mises Stress of Leaf Spring

These post-processing results are find out in patran to show the displacement of multi-leaf spring. Linear static analysis represents the most basic type of analysis. The term 'linear' means that the computed response – displacement or stress, for example – is linearly related to the applied force. The term 'static' means that the forces do not vary with time – or, that the time variation is insignificantly. The deflection of leaf spring is 0.0151 mm.

Maximum Von Mises Stress is 6.22 N/mm²

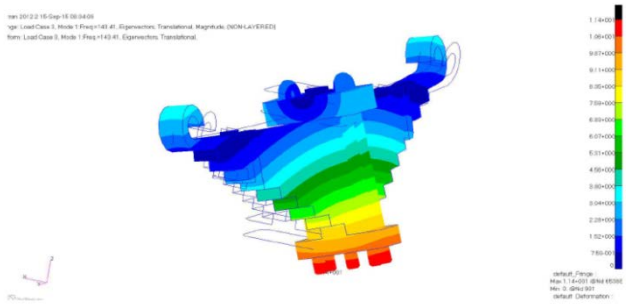


Figure 2.7 Normal Mode 1

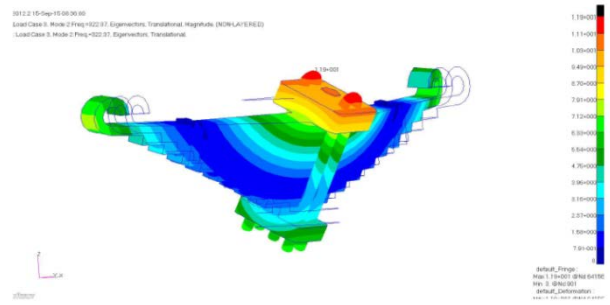


Figure 2.8 Normal Mode 2

Figure 2.9 Normal Mode 3

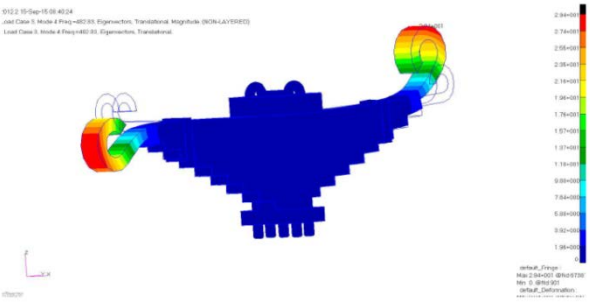


Figure 2.10 Normal Mode 4

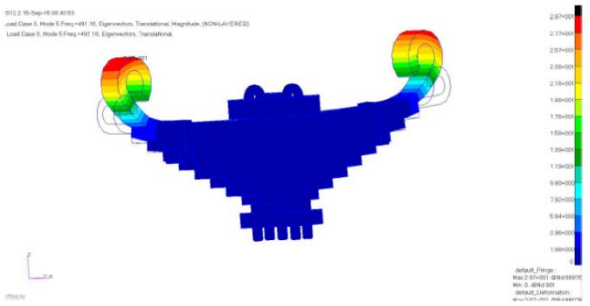


Figure 2.11 Normal Mode 5

Figure 2.12 Normal Mode 6

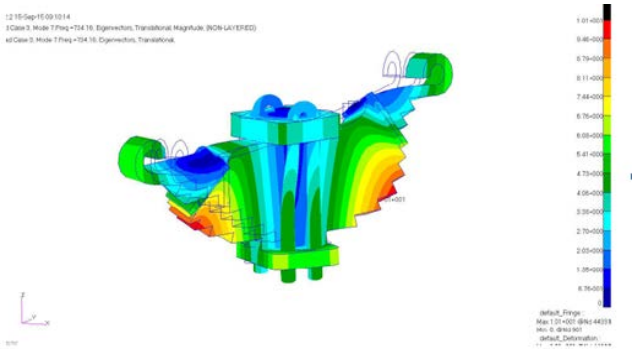


Figure 2.13 Normal Mode 7

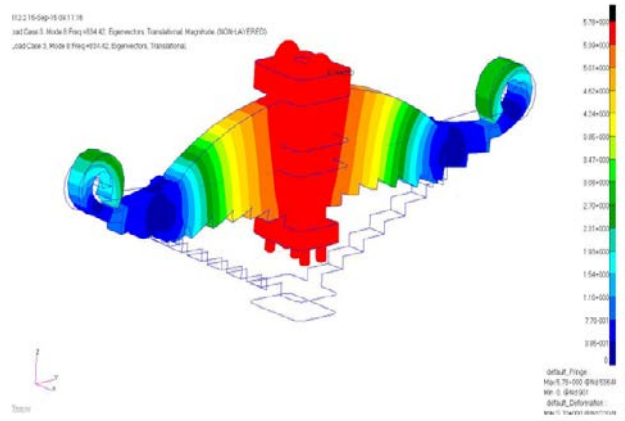


Figure 2.14 Normal Mode 8

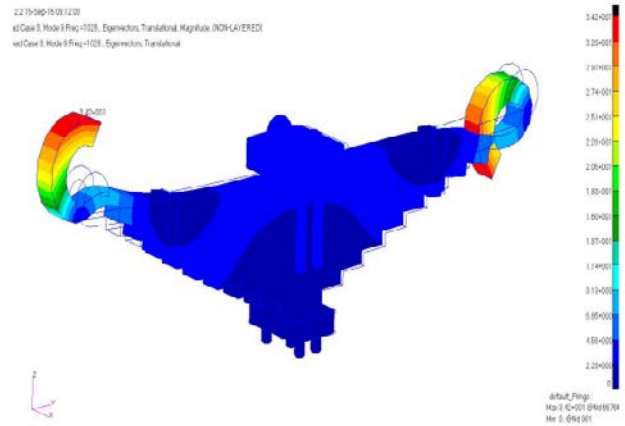


Figure 2.15 Normal Mode 9

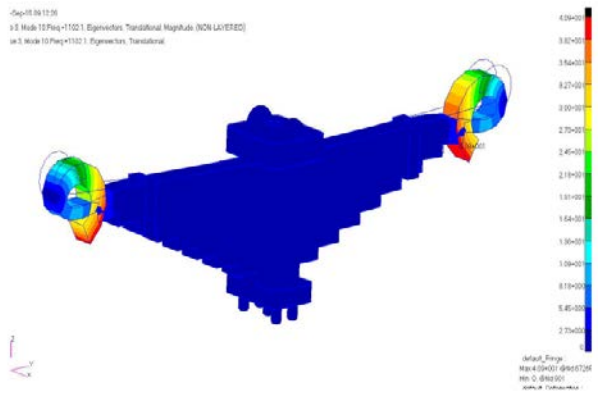


Figure 2.16 Normal Mode 10

Sr. no	Mode Number	Frequency in Hz
1	Mode 1	143.41
2	Mode 2	322.37
3	Mode 3	463.61
4	Mode 4	482.83
5	Mode 5	491.16
6	Mode 6	498.59
7	Mode 7	734.18
8	Mode 8	834.42
9	Mode 9	1028
10	Mode 10	1102.1

Table 2.17: Natural Frequency (Hz) of leaf Spring

In this section we find out deflection, stresses and natural frequency of leaf spring for various normal mode. The mode number represent of leave in leaf spring.

III. PREVIOUS WORK

In this section Baviskar A.C et al published 'Design and Analysis of a leaf spring for automobile suspension system' the aim of this paper is to represent a general study on the design, analysis of leaf spring. The suspension system in a vehicle significantly affects the behavior of vehicle, i.e. vibration characteristics including ride comfort, stability etc. A lot of researches have done for improving the performance of leaf spring. The paper by C.K. Clarke and G.E. Borowski evaluate the failure of leaf spring at different static load conditions and J.J Fuentes et al. study the premature fracture in Automobile leaf springs. Mouleeswaran et al. describes static and fatigue analysis of steel leaf springs and composite multi leaf spring made up of glass fibre reinforced polymer using life data analysis. The dimensions of existing conventional steel leaf springs of a light commercial vehicle are verified by design calculations. Static Analysis of 2-D model of conventional leaf spring is performed using ANSYS 7.1 and compared with experimental results by Mouleeswaran et al. Santosh K Shindhe et al provides 'Static, Modal and Fatigue Life prediction through CAE for a Leaf Spring used in Light Commercial Vehicle'. The CAE technology software such as Hypermesh, Nastran, MSC fatigue and material they are used in Manganese Silicon Steel. The modeling is done on CATIA. It describes static, modal and fatigue analysis of an existing leaf spring and modify existing steel leaf spring by reducing number of graduated leaves and increasing thickness.

IV. ANALYSIS METHODOLOGY

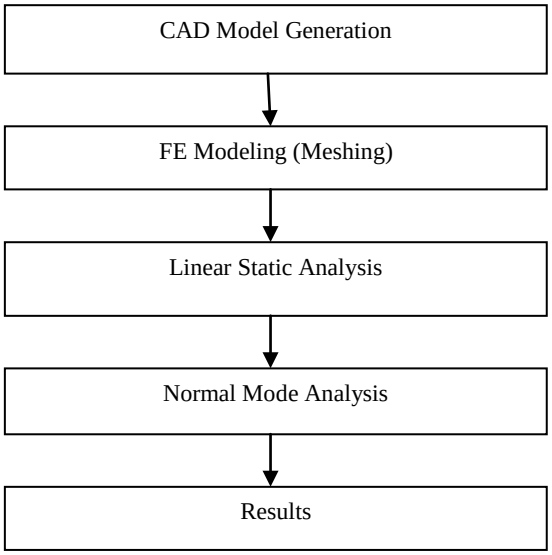
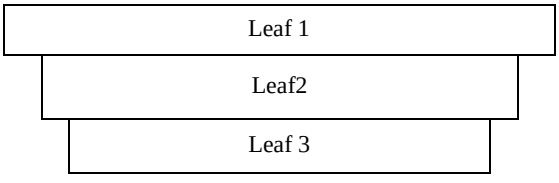


Figure 4: Analysis Flow Chart

In this section the analysis methodology shows by flow chart to achieve the analytical results. The above flow chart is completed in five steps. The first step is CAD Model Generation with the help of CATIA. Next step is FE Modeling (Meshing) of leaf spring by HYPERMESH preprocessor CAE software. Further the analysis is completed by MSC PATRAN and NASTRAN solver for getting approximate solutions.

V. HAND CALCULATION RESULTS

In this section



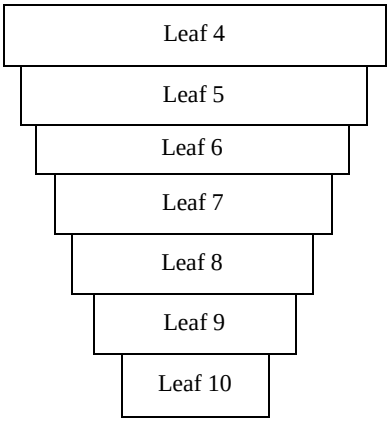


Figure 5: Multi Leaf Spring

Breadth = 40 mm

Thickness = 20 mm

Number of leaves = 10

Varying from = 1000 mm to 100 mm

Deflection of leaf spring is given by:

$$\delta = \frac{6 \times Wg \times L^3}{n \times E \times B \times T^3}$$

Wg = Guess Weight = 16000 kg

L = Length of leave (Major one) =1000 mm = 1 m

n = No. of leaves = 10

E = 200 × 109 N/m²

B = Breadth of leaves = 40 mm = 0.04 m

T = Thickness of leaves = 20 mm = 0.02 m

$$\delta = \frac{6 \times Wg \times L^3}{n \times E \times B \times T}$$

$$\delta = \frac{6 \times 16000 \times 1^3}{10 \times 200 \times 109 \times 0.04 \times 0.02^3}$$

Deflection of leaf spring, $\delta = 0.15$ m

VI. CONCLUSION

The leaf spring is providing the linear static and normal mode analysis of 16 ton truck capacity. This provides the knowledge of leaf spring which is analysed with the help of MSC Nastran, Patran and Hypermesh it shows the deflection and vonmises stress theory to determine the distortion energy of leaf spring with the help of static analysis. Further the normal modes analysis shows the different mode shape and natural frequency determine in normal mode analysis in leaf spring.

VII. FUTURE SCOPES

The future scope of this leaf spring will be done in the design optimisation of leaf spring. In this design optimisation we will perform certain parameters to find out the design sensitivity with the help of various iterations in matrix formulation. The linear static and modal analysis of leaf spring has been done in this research paper the more strength-weight ratio of leaf spring will be found in upcoming researches.

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