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"Critical Analysis of Vibration Behaviourof Multi-Leaf Spring under Loading Condition by ANSYS Software"

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Abstract: *The objective of this paper is to analyze the leaf spring for the constraints such as material composition, vibrations developed in the springs. Vibration analysis plays a very important role in the design of steel leaf spring, since the failure due to vibration is more prominent rather than material failure. In this paper an attempt has been made to predict the vibration behavior of leaf spring under dynamic forces and to check the suitability of steel material.The FE model of the leaf spring has been generated inPro-e and imported in ANSYS-14 for finite element analysis, which are most popular CAE tools. 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. The analytical results are compared with experimentalresults and verified.*
Keywords: *Leaf Spring, FEA, frequency response, vibration,etc.*

I. Introduction

Leaf springs are commonly used in the vehicle suspension system and are subjected to millions of varying stress cycles leading to fatigue failure. A lot of research has been done for improving the performance of leaf spring. The automobile industry has shown interest in the replacement of steel spring with composite leaf spring. The automobile manufacturers can reduce product development cost and time while improving the safety, comfort, and durability of the vehicles they produce with this analysis. Also during the analysis, the leaf spring is subjected to frequency with which the leaf spring has to operate most of the times in the vehicles. The aim of this paper is to represent a general study on the design, analysis of leaf spring.Nevertheless, we usually reserve the word SPRING to mean a machine element whose primary function is to undergo relatively large deflection of some kind, thereby storing a relatively large amount of strain energy.Depending on the application, it may also be important to be able either to recover the stored energy without excessive losses, or to absorb (or dissipate) as much of the stored energy as possible in order to prevent rebound.In other applications, such as vibration absorption, it is of advantage to have the absorbed energy dissipated within the spring the characteristics of a material such as rubber or polymer.The energy storage mode is important for a number of reasons and will vary to suit the application.

Sugiyama et al. [1] suggests that existing leaf spring models can roughly be classified into three categories; (1) a lumped spring model, (2) a discretized model, where a number of rigid links, connected by springs and dampers, are used to account for the structural flexibility of the spring blades and (3) finite element models.

Fancheret al. [2]measured the force-producing characteristics of several different types of leaf springs while exciting them at various amplitudes and frequencies of oscillation about nominal loading conditions and develop a means for representing the force deflection characteristics of leaf springs in a form suitable for use in simulations of commercial vehicles.

Cebonet al.[3] describes an experimental investigation into the behavior of some typical leaf springs for realistic operation conditions.

Hoyleet al.[4] extended his leaf spring model to include the relaxation and recovery regimes generated by the rubber bushes used in the suspension system. This was modeled as a spring in series with a damper/coulombfriction element.

Erdogan KILIC et al. [6] present a leaf spring model that can be used in road load simulations. They model the leaf spring in a similar way to the model .The model parameters are identified from static force-deflection test data.

C.K. Clarke and G.E. Borowski et al. [7] report a systematic methodology which is used to evaluate and improve vehicle ride comfort. The vehicle dynamics model of a tractor with tandem suspension is modelled and simulated in ADAMS.

S. S. Raoet al.[15] presents a finite element algorithm to address the contact problem encountered in multi-leaf springs.

O.P.Khanna et al.[17]model the multi-leaf spring as four links with two torsional springs, two bushings and a revolute joint. They state that when modelled in this way the model can represent the behaviour of a multi-leaf spring even when a braking force is applied to the wheel.

Autar.K.Kawet al.[18] state that their experience with the 3 link leaf spring model is that it has difficulty predicting the lateral loads accurately. One of the reasons they contribute the lack of accuracy to, is that the 3 link leaf spring model cannot represent the roll behaviour of the actual suspension very well.

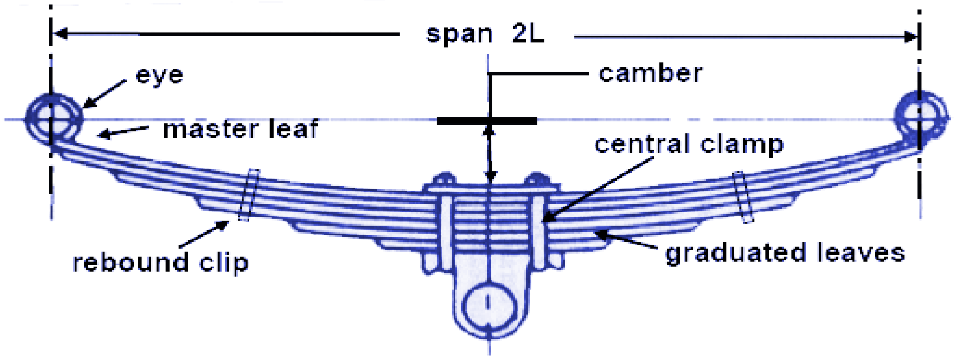

Figure-1 Leaf Spring

II. Methodology

A. Objective of Project:

The main objectives of present paper are:-

1. To carry out finite element analysis of composite leaf spring and analytical validation of it.
2. To study vibration characteristic of leaf spring. The leaf spring should absorb the vertical vibrations and impacts due to road irregularities by means of variations in the spring deflection so that the potential energy is stored in spring as strain energy and then released slowly. So, increasing the energy storage capability of a leaf spring ensures a more compliant suspension system.
3. Modelling the leaf spring without losing its geometry in Pro/engineer software.
4. Analyse and Compare the various stresses, strain and safety factors of the model of Leaf Spring FEM tool ANSYS.
5. Perform parametric study to study the effect of varying load on the various stresses, strains on the Leaf Spring Model.

B. Specification of The Leaf Spring

The test steel leaf spring used for experiment is made up of Steel. The composition of material is 0.91C%, 1.80 SI%, 0.70 Mn%, 0.045 P%, 0.045 S%. Before testing of the leaf spring Shot Peening is done on all leaves**.** The leaves used are in Hardened and tempered state.

Table No. 01

Parameter	**Value**
Total length of spring	1540 mm
No. of full length leaves (Master Leaf)	01
Thickness of leaf	13 mm
Width of leaf spring	60 mm
Ultimate tensile strength	1680-2200 Mpa
Tensile yield	1540-1750 Mpa
Number of graduated leaves	05

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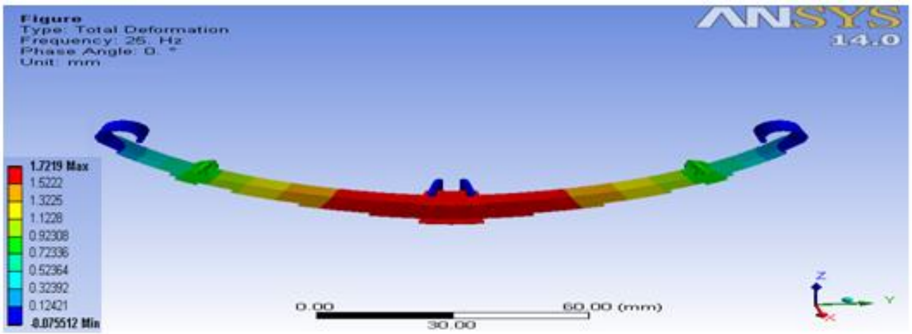
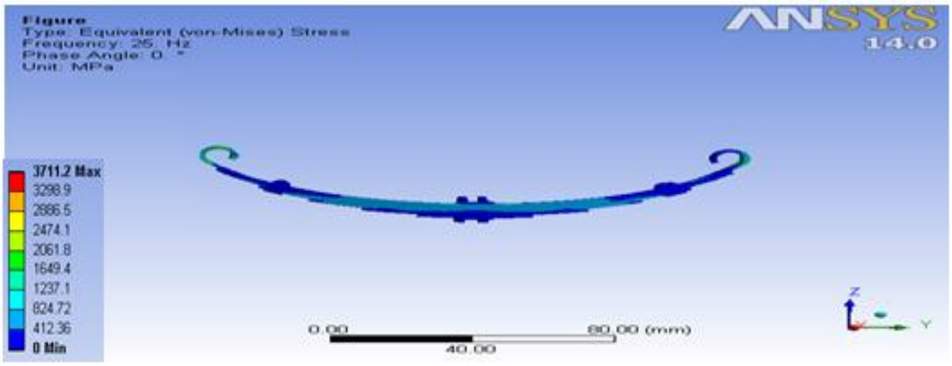
C. FEA Analysis

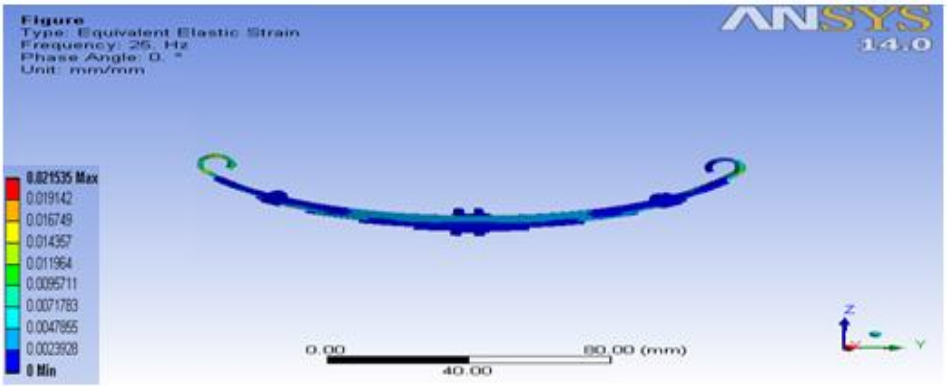
C. 1. Total Deformation of Leaf Spring



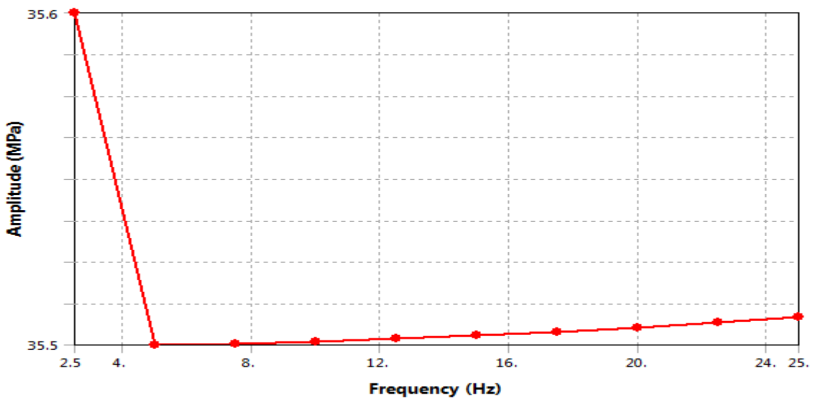
C. 2. Equivalent Stress of Leaf Spring



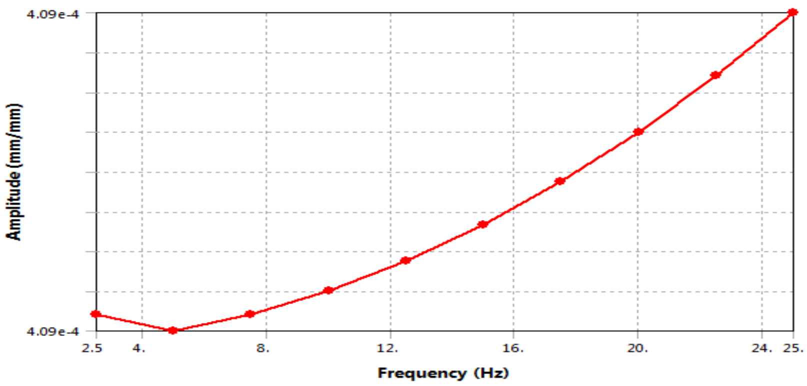
C. 3Equivalent Elastic Strain of Leaf Spring



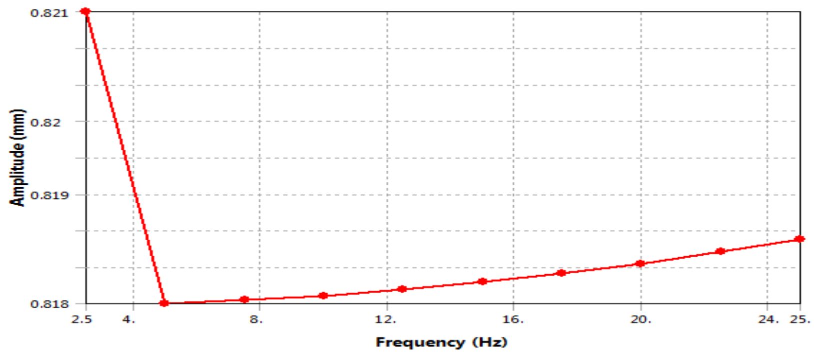
C. 4Graphical Representation of Frequency response of Stress



C.5 Graphical Representation of Frequency response of Strain



C. 6 Graphical Representation of Frequency response of Deformation



III. Result

Table No. 02: Maximum and Minimum Values of Leaf Spring

Sr.no.	**Object Name**	**Result**	
		Minimum	**Maximum**
1	Total Deformation	0. mm	1.7219 mm
2	Directional deformation	-0.0755 mm	1.7219 mm
3	Equivalent Stress	0. MPa	3711.2MPa
4	Equivalent Elastic Strain	0. mm/mm	0.021535 mm/mm
5	Shear Stress	0MPa	2129.4 MPa

Table No. 03

Object Name	**Stress Frequency Response**	**Frequency Response strain**	**Frequency Response deformation**	**Phase Response stress**	**Phase Response strain**
Maximum Amplitude	35.647 MPa	4.09e4 mm/mm	0.821mm	0.81837 MPa	4.09e-0.004 mm/mm
Frequency	5. Hz	5 Hz			
Phase Angle	180 °	180. °		180°	
Real	-35.647 MPa	-4.09e.004 mm/mm	0.8216 mm	-35.506 MPa	-
Imaginary	0 MPa	0 mm/mm	0mm	0 MPa	0 mm/mm
Reported Frequency	25 Hz			25. Hz	

IV. Conclusion

In this thesis report,FEM approach has used for predicting the stress and deformation .A parametric study is also made by varying the load to investigate their effect on the stress of leaf spring .A frequency response graph is plotted to analyse the effect of Stress, Strain and Deformation.. The stiffness of whole system does not decreases with the increase in frequency which guarantees the reliability of the selected material of leaf spring. The combination of frequency and amplitude is found to be most efficient method for reducing or controlling applied force which generate stress.

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