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DESIGN AND ANALYSIS OF LEAF SPRING WITH 9 PLATES USING DAMPER FOR VEHICLE

Manisha Singh*[1] and Ms. Divya Chaturvedi[2]
*[1]Student, M.E. IVth Semester (Machine Design), Department of Mechanical Engineering, Jabalpur Engineering College, Jabalpur (MP)-482011, India
[2]Assistant Professor, Department of Mechanical Engineering, Jabalpur Engineering College, Jabalpur (MP)-482011, India

ABSTRACT
Leaf springs are commonly used in the vehicle suspension system and are subjected to absorb the vehicle vibration, shock bump loads (induced due to road irregularities) by means of spring deflection. The study on the design, analysis of leaf spring, we can use dampers with the leaf spring so it can increase leaf spring service life. The main achievement of having this new design is to improve shock absorb quality and increase the overall life of the leaf spring. The design is done using the CATIA software and the analysis is completed using ANSYS with experimental setup.

Keywords- *Leaf spring (EN45A Steel flat), damper, Catia, Ansys.*

I. INTRODUCTION
A spring is defined as an elastic machine element, which deflects under the action of the load and returns to 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. The leaf spring is based upon the theory of a beam f uniform strength.

Leaf spring: A multi-leaf or laminated spring consists of a series of flat plates, usually of semi-elliptical shape. The flat plates called leaves have varying lengths. The leaves are held together by means of U –bolts and a centre clip. The longest leaf called the master leaf is bent at the two ends to form spring eyes. The leaves of multi-leaf spring are subjected to bending stresses. Multi –leaf springs are widely used in automobile and railroad suspension. Usually the eyes, through which the spring is attached to the hanger or shackle, are provided with bushings of some antifriction material such as bronze or rubber. The other leaves of the spring are known as graduated leaves. In order to prevent digging in the adjacent leaves, the ends of the graduated leaves are trimmed in various forms.

Damper: damping refers to the energy dissipation properties of a material or a system under cyclic stress but excludes energy transfer device. When a structure is subjected to an excitation by an external force then it vibrates in certain amplitude of vibration, it reduces as the external force is removed. This is due to some resistance offered to the structural member which may be internal or external. This resistance is termed as damping.

CATIA software: CATIA (Computer Aided Three Dimensional Interactive Application) developed by Dassault Systems, is one of the world's leading CAD/CAM/CAE packages. Being a solid modelling tool, it not only unites the 3D parametric features with 2D tools, but also addresses every design- through-manufacturing process. CATIAV5 serves the basic design tasks by providing different workbenches.

ANSYS software: Ansys is general–purpose finite element analysis (FEA) software package. Finite element analysis is a numerical method of deconstructing a complex system into very small pieces (of user – designated size) called elements. The software implements equations that govern the behavior of these elements and solves them all creating a comprehensive explanation of how the systems act as a whole. These results then can be presented in tabulated or graphical form. These types of analysis is typically used for the design and optimization of a system far too complex to analyze by hand.

Mahmood M. Shokrieh Davood Rezaei (11) A four-leaf steel spring used in the rear suspension system of light vehicles is analyzed using ANSYS V5.4 software. The finite element results showing stresses and deflections verified the existing analytical and experimental solutions. Using the results of the steel leaf spring, a composite one made from fiberglass with epoxy resin is designed and optimized using ANSYS. **Sean D'Silva, Sumit Jain (15)** This paper explains the design of new type of leaf spring which has an integrated damper system. The main objective of having this new design is to improve ride quality and increase the overall life of the leaf spring in general by reducing the intensity of forces on its surface. By implementing this design, the forces acting on it are distributed to the two dampers and to the bottom of the leaf. The results are compared with that of a standard leaf spring. **Krishan Kumar and M. L. Aggarwal** (9) The purpose of this work is to make computer aided engineering (CAE) analysis of mono parabolic leaf spring and to see the effect of change of material in the optimized leaf. A mono steel leaf spring and a mono leaf spring made of composite material have been selected for this comparative analysis. The mono leaf spring model is having one full length leave with eyes at both ends, two pins in each eye end and a rubber pad on the upper face of leave center. The CAD modeling of parabolic leaf spring has been done in CATIA and for analysis the model is imported in ANSYS workbench. **Hiroyuki Sugiyama a, Ahmed A. Shabana a,*, Mohamed A. Omar b, Wei-Yi Loh c (6)** In this investigation, a nonlinear elastic model of leaf springs is developed for use in the computer simulation of multi body vehicle systems. In the leaf spring model developed in this investigation, the distributed inertia and stiffness of the leaves of the spring are modeled using the finite element floating frame of reference formulation that accounts for the effect of the nonlinear dynamic coupling between the finite rotations and the leaf deformation **Jadhav Mahesh V, Zoman Digambar B, Y R Kharde, R R Kharde(8)** In this paper we look on the suitability of composite leaf spring on vehicles and their advantages. Efforts have been made to reduce the cost of composite leaf spring to that of steel leaf spring. The achievement of weight reduction with adequate improvement of mechanical properties has made composite a very replacement material for convectional steel. **V. Noresson, N.G. Ohlson*, M. Nilsson (19)** this material model displays no frequency dependence but, if required, the model may be modified to account for frequency dependence by introducing strain-rate sensitive friction. The paper describes how this is done. The application of an ER damper to a Laval rotor system was studied. The system response to stationary as well as to some transient loads was derived by a time integration technique in Matlab. The results agree well with those obtained from a small Laval rotor test rig. One concludes that the force-displacement hysteresis loop can be predicted by FE calculation for any damper design. The loop may then be simplified so as to be described by only two parameters for ensuing transient response analysis. **Ashvini P.lad, Prof.B.S.gandhare, Prof.A.S.Aradhye, Prof.N.V.Hargude (1)** In Automobile sector leaf spring of steel material which is used in suspension system .The current leaf spring is multiple leaf spring types with a steel material. Current issue in Automobile is to reduce the weight of product by maintaining its strength. Therefore it can be replaceable by composite material due to its high strength to weight ratio. The objective of this paper is to present analysis of deflection of composite leaf spring (epoxy carbon fiber) to the conventional steel leaf spring through FEA software ie in Ansys.**M Senthil Kumar and S Vijayarangan(10)** This paper describes static and fatigue analysis of steel leaf spring and composite multi leaf spring made of glass fibre reinforced polymer. Primary objective is to compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. The design constraints are stresses and deflections. Finite element analysis with full bump load on 3-D model of composite multi leaf spring was done using ANSYS 7.1 and analytical results were compared with experimental results.

II. EXPERIMENTAL SETUP

We have done our experiment in spring test. Which is shown in fig 3.there is a leaf spring with 9 leaf.2 damper on the each leaf eyes, used to absorb the vibration of the system.

Leaf spring: A multi-leaf or laminated spring consists of a series of flat plates, usually of semi-elliptical shape. The flat plates called leaves have varying lengths. We have used a 9 leaf.

Fig 1 Leaf spring

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Damper (Helical spring) : The helical spring is made from a wire, usually of circular cross section, which is bent in the form of a helix.

Fig2 Damper

III. EXPERIMENT PROCEDURES

We have our experiment on leaf testing machine first we measures a length and deflection of the leaf spring then we placed a leaf spring with 9 leafs on spring testing machine bed which is fixed by both end. Then we apply five different 0.02, 0.04, 0.06, 0.08, 0.10 ton load on the leaf spring in the centre position of the spring by the spring testing machine. Then we measure the

Length and deflection of the leaf spring by the measuring tape which is shown in fig 3. Then we fixed a damper which is shown in figure 2 on the leaf on the both side of the spring then again we followed the same procedure.

Fig3 EXPERIMENTAL SETUP

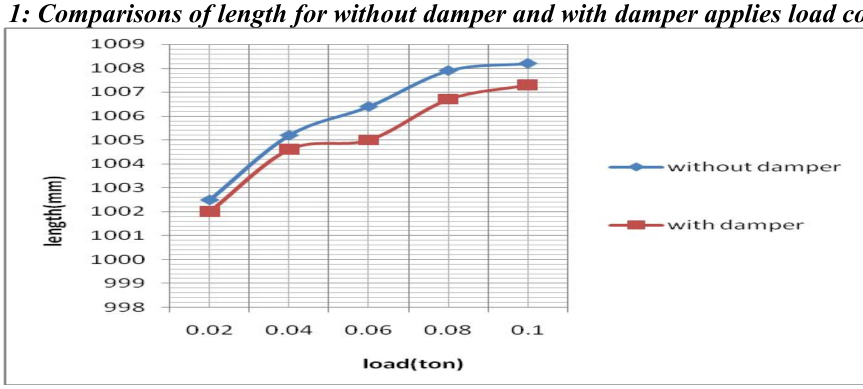
System description

S.NO	Components	parameter	dimensions
1	Leaf spring	Number of plates	9
		length	1000mm
		width	40mm
		thickness	5mm
2	Damper	pitch	15mm
		diameter	60mm
		height	240mm
3	Nut	diameter	20mm
4	Bolt	diameter	20mm
5	Measuring tape		-

Table 1.Observation reading of length for without damper and with damper applies load condition

S.NO	LOAD(Ton)	LENGTH(mm)	
		Without damper	With damper
1	0.02	1002.5	1002
2	0.04	1005.2	1004.6
3	0.06	1006.4	1005
4	0.08	1007.9	1006.7
5	0.10	1008.2	1007.3

Graph 1: Comparisons of length for without damper and with damper applies load condition

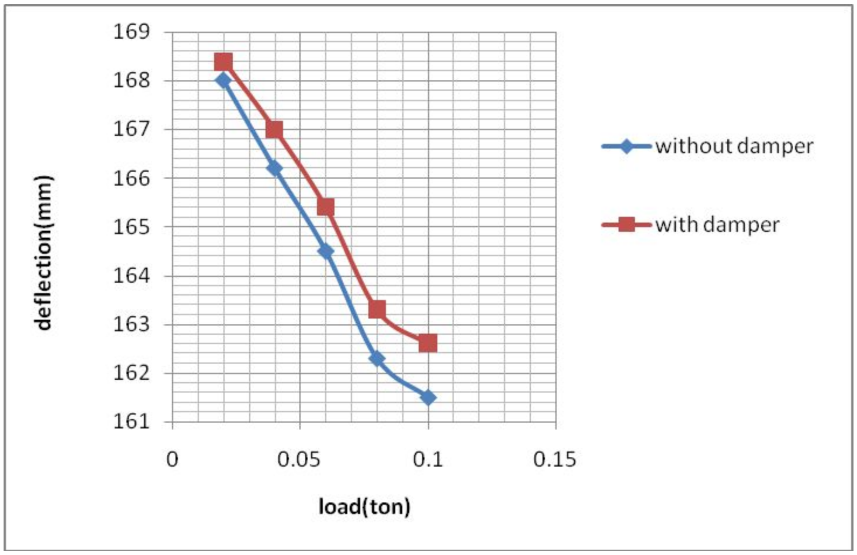


This graph 1 shows that the length of spring in different load (0.5 to2.5 ton) condition with damper compare to without damper. We found that the length of leaf spring decreasing with damper compare to without damper.

Table 2.Observation reading of deflection for without damper and with damper applies load condition

S.NO	LOAD(Ton)	DEFLECTION(mm)	
		Without damper	With damper
1	0.02	168	168.4
2	0.04	166.2	167
3	0.06	164.5	165.4
4	0.08	162.3	163.3
5	0.10	161.5	162.6

Graph Comparisons of deflection for without damper and with damper applies load condition



This graph 2 shows that the deflection of leaf spring with and without damper, we found that the deflection of leaf spring is increasing with damper compare to leaf spring without damper.

IV. SOFTWARE ANALYSIS

We design a leaf spring in catia V5R16 of dimensions shown in table 1.then we import the design in ANSYS14.0.then mesh was (Dividing the model into small elements) Material property and geometry data were defined. The Environment (a combination of loads and supports) was defined follows: force: 0.5N to 2.5N. The Model was submitted to the ANSYS solver and the solutions for the Equivalent von-Miss stress, Total Deformation and Stress Tool were obtained.

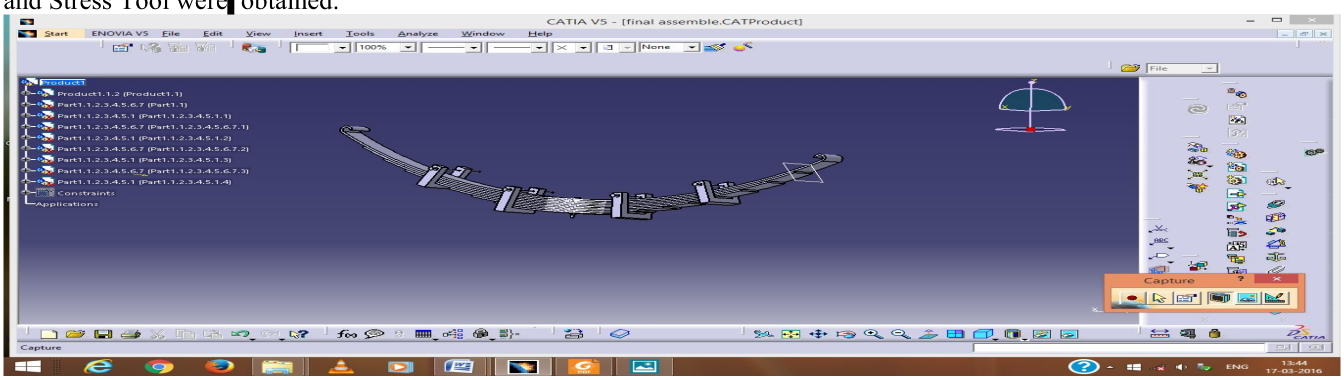


Fig.4 leaf spring of design in catia

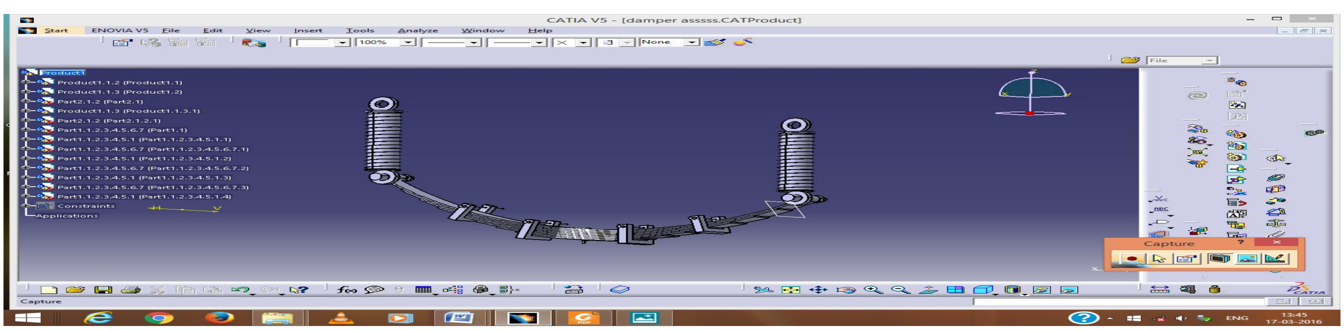


Fig.5 leaf spring in with damper of design in catia

a) Comparison maximum principal stress of leaf spring with damper and without damper

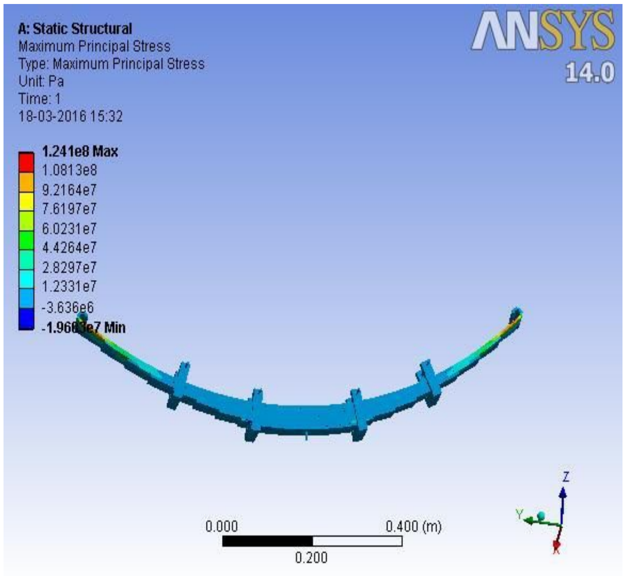


Fig 4 without damper

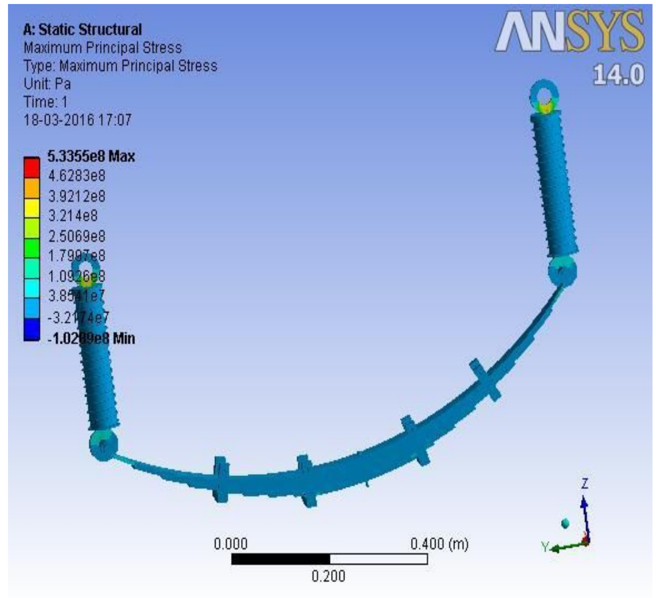


Fig5with damper

b) Comparison total deformation of leaf spring with damper and without damper

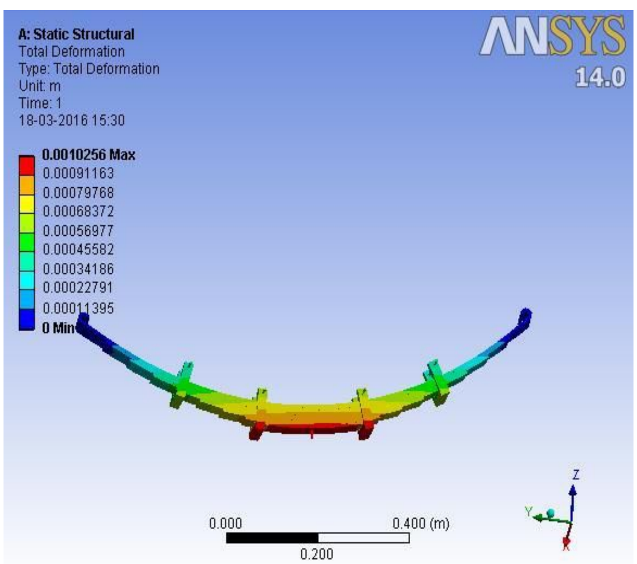


Fig 6 without damper

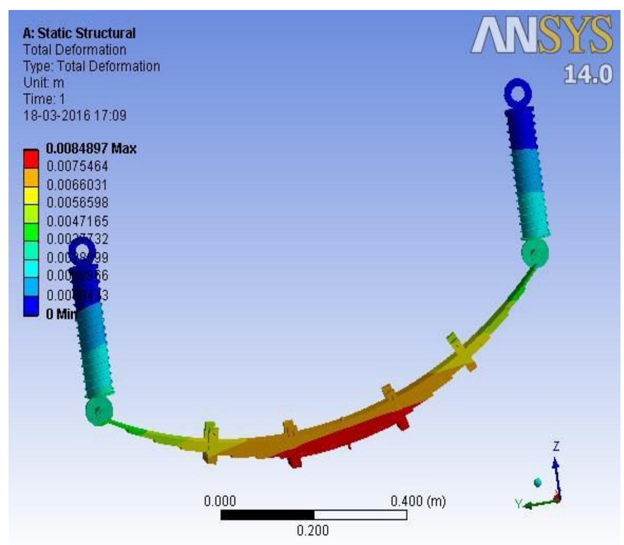


Fig 7with damper

Table 3 Software result comparison of leaf spring with and without damper

s.no	Parameter	Without damper	With damper
1	Maximum principal stress	1.241e8 max.	5.335e8max.
2	Total deformation	0.00102566max.	0.00848max.

V. CONCLUSION

The main objective of having this new design is to improve shock absorb quality and increase the overall life of the leaf spring. . We can use of damper with the leaf spring so it can increase leaf spring service life

1. **The following are the main conclusions of this experimental investigation**:

- The experimental results show that the length of leaf spring with damper is decreasing compares to without damper.
- We found that the deflection of leaf spring is increasing with damper compare to leaf spring without damper.

2. **The following are the main conclusions of this software investigation**:

- The result shows that Maximum principal stress without damper1.241e8 max. and

  with damper 5.335e8max.

- The result shows that Total deformation without damper 0.00102566max. With damper 0.00848max.

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