Review On Design Optimization And Vibration Analysis Of Heavy Duty Leaf Spring By Using CAD Tool.

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Abstract: *Leaf spring sets are mostly used in heavy duty vehicles to absorb shocks during running of vehicle. It is most popular and widely used component in suspension system for heavy duty vehicles. It is nothing but a set of metal strips which are grouped together in ascending order with respect to length. A central bolt is provided to hold all strips together.*

It continuously works in worst conditions and absorbs shocks. Also it holds the entire weight of the vehicle. Hence the failure may accurse rapidly in leafs. To avoid failure periodic inspection and maintenance is carried out. There are several other reasons of failure which depends on particular situation.

In this paper, the available literature is studied well and their explanations are given briefly. Also from this study the all possible troubleshoots and failure reasons are summarized. On the basis of this study outcomes were drawn.

Key Words: **Lead spring set, leaf spring failure, periodic inspection**

1. Introduction

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. The advantage of leaf spring over helical spring is that the ends of the spring may be guided along a definite path as it deflects to act as a structural member in addition to energy absorbing device. According to the studies made a material with maximum strength and minimum modulus of elasticity in the longitudinal direction is the most suitable material for a leaf spring. [1]

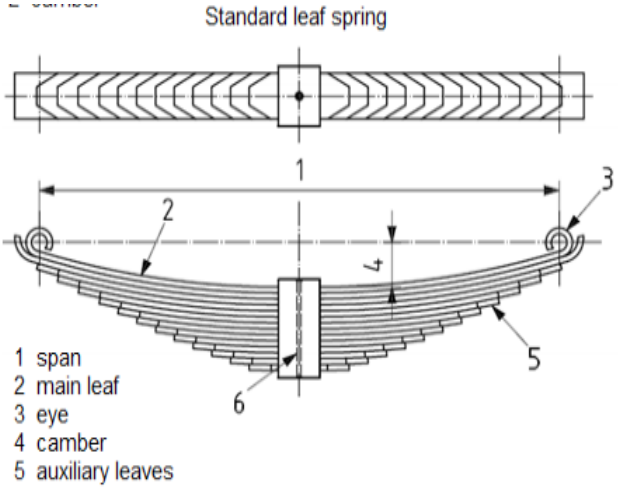

Fig. 1: Standard Leaf Spring Set. [2]

The advantages of the leaf spring are based on its simple construction, low costs and easy maintenance. The design also provides the solution for the axle support. Almost all vehicle suspension uses parabolic leaf springs. The difference between the normal leaf spring and the parabolic leaf spring is the total number of leafs. A parabolic leaf does not need of huge amount of leafs because the stress is distributed equally due to its parabolic shape.

2. Literature Survey

Pankaj Saini[1], Ashish Goel[2], Dushyant Kumar[3], " Design and Analysis of Composite Leaf Spring For Light Vehicles". In their paper they described design and analysis of composite leaf spring. The objective is to compare the stresses and weight saving of composite leaf spring with that of steel leaf spring. The design constraint is stiffness. The material selected was glass fiber reinforced polymer (E-glass/epoxy), carbon epoxy and graphite epoxy is used against conventional steel. The design parameters were selected and analyzed with the objective of minimizing weight of the composite leaf spring as compared to the steel leaf spring. The leaf spring was modeled in Auto-CAD 2012 and the analysis was done using ANSYS 9.0 software. [1]

T.N.V.Ashok Kumar, E.Venkateswara Rao, S.V.Gopal Krishna, "Design and Material Optimization of Heavy Vehicle Leaf Spring". Their paper describes static and dynamic analysis of steel leaf spring and laminated composite Multi leaf spring. The objective is to compare displacement, frequencies, deflections and weight savings of composite leaf spring with that of steel leaf spring. The dimensions of an existing conventional steel leaf spring of a Light design calculations. Static and Dynamic Analysis of 3-D model of conventional leaf spring is performed using ANSYS 10.0. Same dimensions are used in composite multi leaf spring using S2 Glass/Epoxy and Kevlar/Epoxy unidirectional laminates. Analysis is done by layer stacking method for composites by changing reinforcement angles for 3 layers, 5 layers and 11 layers. The weight of composite leaf spring is compared with that of steel leaf spring. The design constraints are stresses and deflection. A weight reduction of 27.5 % is achieved by using composite leaf spring. [2]

A.K.Tarange1, Prof. M. B. Bankar2, Dr. A. M. Badadhe 3, " Design, Optimization And FE Analysis of Composite Mono Leaf Spring". The paper illustrate that, the dimensions of an existing mono steel leaf spring of a Maruti Alto 800 passenger vehicle is taken for modeling and analysis of modeling and analysis of a laminated composite mono leaf spring with glass fiber composite material. [3]

Suraj B. Pawar,Rohit R. Ghadge, "Design & Analysis of Multi Steel Leaf Spring". The main scope of this study illustrated in their paper is to design, analyze & manufacture a hybrid composite multi leaf spring for a multi utility vehicle. The objective is to compare the load carrying capacity, stiffness & weight of a Hybrid composite leaf spring with the present conventional steel multi leaf set-up. The primary design considerations are deflection, maximum stress induced & fatigue life. In automobile sector leaf spring which is used in a suspension system can be replaceable by a novel concept of hybrid fiber metal composite material hence by combining the mechanical properties of composite fiber and metal to resist high mechanical loads and thereby increasing higher fuel economy and decrease the overall weight of the vehicle. Experimental test rig (endurance test rig) has been used for fatigue analysis of hybrid fiber-metal composite leaf spring. This method provides means to determine the deflection, stress and strain for different loading conditions. The model of leaf spring has been prepared to carry out Finite Element Analysis. [4]

Prof. N.P.Dhoshi, Prof .N.K.Ingole, Prof .U.D.Gulhane, "Analysis and Modification of Leaf Spring of Tractor Trailer Using Analytical and Finite Element Method". In their work analytical and Finite element method has been implemented to modify the existing leaf spring with consider the dynamic load effect. Leaf spring manufactured by Awachat industries Pvt. Limited has been selected for stress analysis. One of the important areas where one can improve the product quality while keeping the cost low is the design aspect. One can design the product in such a way that its performance increases while the customer has to pay less as compared to the same product of other companies. Material and manufacturing process are selected upon on the cost and

strength factor whereas the design method is selected on the basis of mass production. FEM and ANSYS software ensures a healthy approach of designing the leaf spring thus epitomizing the traits that are essential for the manufacturing. [5]

Sushanta Ghuku and Kashi Nath Saha, "Design Development and Performance Analysis of Leaf Spring Testing Set Up in Elastic Domain". Their paper presents design development and performance analysis of two different leaf spring testing rigs. The design considerations, detail descriptions of the components along with their manufacturing details are furnished here. The first set-up is a general purpose set-up for clamping structures, which models leaf spring as curved cantilever beam under tip concentrated load by considering only its one half. Experiment is carried out in their set-up to obtain deflection profiles of master leaf spring using image processing technique. To overcome such insufficiencies, the second set-up is designed which simulates three point bending test. This set-up introduces roller supports at eye ends and considers asymmetry in the master leaf geometry. [6]

Mayur D. Teli, Umesh S. Chavan, Haribhau G. Phakatkar, "Design, Analysis and Experimental Testing of Composite Leaf Spring for Application in Electric Vehicle". In their study glass fiber is used to analyze the application of leaf spring for excess weight in electric vehicle. The main objective of their study is to investigate feasibility of composite material for leaf spring to withstand the excess load in Electric vehicle. Rear leaf spring of TATA Sumo passenger vehicle is considered as case study model, which is semi-elliptical laminated type. The CAD model was created in CATIA & imported to ANSYS. Analytical, Experimental and Finite Element Analysis were carried out on composite prototype. Weight optimization of 67.70% for GFRP is observed in comparison to EN 46 material. For deflection 3.93%, for stiffness 4.06%, for energy absorbed 3.94% and for natural frequency is 5.25% difference is observed. [7]

Hemant Rajendra Nehete, "Vibration Analysis of Composite Leaf Spring by Finite Element Method". Author have explained that the "vibration is an oscillation wherein the quantity is a parameter that defines the motion of a mechanical system". The main causes of vibration are unbalanced forces in the machine, dry friction between the mating surfaces, external excitation, earthquakes, wind self-excited vibrations, misalignment of rotating shaft, looseness in rotating machinery, loose foundations and excessive bearing clearances, oil whirl in bearing. The harmful effects of vibrations are excessive stresses in machine parts and undesirable noise. Also due to high vibration there are looseness of parts and partial or complete failure of parts. This vibration can be reduced by removing the causes of vibration, by vibration isolation. Also vibration can be controlled by using shock absorbers and by installing dynamic vibration absorbers. Using composite material also vibration reduce. Automobile suspension Leaf spring consist high vibration during motion. By binding the composite material to steel spring the vibration can be reduced. ANSYS software used for Finite Element Analysis for vibration analysis. [8]

P. Ravindranatha Reddy, K. Suresh Kumar, "Mono Composite Leaf Spring – Design and Analysis by using FEA Under Static Load Condition". The aim of their paper is to design a spring with minimum weight that is capable of carrying given static external forces without failure. A single leaf with variable thickness and width for constant cross sectional area of unidirectional Glass Fiber Reinforced Plastic (GFRP) with similar properties as that of a multi-leaf spring is designed and analyzed by considering bending stress and deflection as design constraints using ANSYS 13.0. C-Program has been used for the design of constant cross-section leaf spring. The results showed that spring width decreases and thickness increases from the spring eyes towards the axle seat. The finite element results obtained for stresses and deflection using ANSYS software are verified with analytical results and found that results are close to the

analytical values. Compared to the steel spring, the composite spring has stresses that are much lower and the spring weight is nearly 80% lower. [9]

A. Sivasankar , Mr. B. Ramanathan, "Design and Numerical Investigation of Static and Dynamic Loading Characters of Heterogeneous Model Leaf Spring". In their paper, a heterogeneous model leaf spring system is developed and numerically tested for a better suitability for the existing model. This model will introduce synthetic rubber sleeves between spring leafs, which is a hyperrealist material in nature, this system is designed and modeled through CAD software, dimensions and loading data are arrived from literature reviews. FEA based static and dynamic analysis will be conducted to study the behaviors of existing and heterogeneous models and the effectiveness of new model will be evaluated. The heterogeneous model is very economical alternative to many composite models proposed in the literature review and easy to manufacture, recyclable, and maintainable. [10]

Syambabu Nutalapati, "Design and Analysis of Leaf Spring by Using Composite Material for Light Vehicles", In his paper he described design and analysis of composite leaf spring. For this purpose, a rear leaf spring for MAHINDRA "MODEL-COMMANDER 650 DI" is considered. The main objective is to compare the stresses, deformations and weight saving of composite leaf spring with that of steel leaf spring. The design constraint is stiffness. The material selected was glass fiber reinforced polymer (E-glass/epoxy) is used against conventional steel. Result shows that, the weight of composite leaf spring was nearly reduced up to 85% compared with steel material. The leaf spring was modeled in Pro/ENGINEER and the analysis was done using ANSYS 12.0 software. The fatigue life of both steel and composite leaf is compared using ANSYS software. [11]

Vinkel Kumar Arora, Gian Bhushan, and M. L. Aggarwal, "Fatigue Life Assessment of 65Si7 Leaf Springs: A Comparative Study". This paper provides alternate methods for fatigue life assessment of leaf springs. A 65Si7 light commercial vehicle leaf spring is chosen for this study. The experimental fatigue life and load rate are determined on a full scale leaf spring testing machine. Four alternate methods of fatigue life assessment have been depicted. Firstly by SAE spring design manual approach the fatigue test stroke is established and by the intersection of maximum and initial stress the fatigue life is predicted. The second method constitutes a graphical method based on modified Goodman's criteria. In the third method codes are written in FORTRAN for fatigue life assessment based on analytical technique. The fourth method consists of computer aided engineering tools. The CAD model of the leaf spring has been prepared in solid works and analyzed using ANSYS. Using CAE tools, ideal type of contact and meshing elements have been proposed. The method which provides fatigue life closer to experimental value and consumes less time is suggested. [12]

3. Conclusion

1) Composite material can be used for life improvement of leaf spring set.
2) FEA tool is the best tool to analyze performance of leaf spring.
3) Vibrations generated within lead spring set must be controlled.
4) Many authors have focused on material change, CAD modeling and FEA Analysis.
5) Tension retaining must be done periodically to improve life of leaf spring.
6) Very less work is available on dynamic Loading on leaf spring set. Hence more research is needed in this era.

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