Stress Analysis of Multi Leaf Spring by using FEM and Experimental Method -A Review

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Abstract— Leaf springs are used in vehicles for suspension purpose in all type of vehicles. Ample amount of work has been done on the analysis of leaf spring. Researcher focused on the analysis of stresses developed in spring by using different FEM tool also several worked on predict fatigue life of leaf spring. After review of available literature on leaf spring it is found that the very few literature is available on analysis of springs used for light commercial vehicle. Also there is scope of experimental analysis of spring by using different methods like photoelasticity and strain gauge.

Key words: Leaf Spring, FEM, Fatigue Failure

I. INTRODUCTION

A leaf spring is a simple form of spring commonly used for the suspension in wheeled vehicles. Originally called a laminated or carriage spring, and sometimes referred to as a semi-elliptical spring or cart spring, it is one of the oldest forms of springing, dating back to medieval times A leaf spring takes the form of a slender arc-shaped length of spring steel of rectangular cross-section. In the most common configuration, the center of the arc provides location for the axle, while tie holes are provided at either end for attaching to the vehicle body. For very heavy vehicles, a leaf spring can be made from several leaves stacked on top of each other in several layers, often with progressively shorter leaves. Leaf springs can serve locating and to some extent damping as well as springing functions. While the interleaf friction provides a damping action, it is not well controlled and results in stiction in the motion of the suspension. For this reason some manufacturers have used mono-leaf springs.

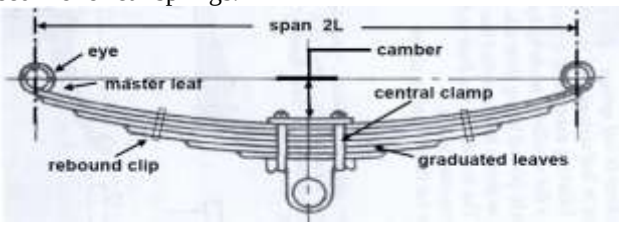

Fig. 1: Laminated semi-elliptic spring

II. HISTORY

Leaf spring was very common on automobiles, right up to the 1970s in Europe and Japan and late 70's in America when the move to front wheel drive, and more sophisticated suspension designs saw automobile manufacturers use coil springs instead. Today leaf springs are still used in heavy commercial vehicles such as vans and trucks, SUVs, and railway carriages. For heavy vehicles, they have the advantage of spreading the load more widely over the vehicle's chassis, whereas coil springs transfer it to a single point. Unlike coil springs, leaf springs also locate the rear axle, eliminating the need for trailing arms and a Panhard rod, thereby saving cost and weight in a simple live axle rear suspension.

III. REVIEW OF LITERATURE

J.J. Fuentes a, H.J. Aguilar, J.A. Rodrıguez, E.J. and Herrera worked on 'premature fracture in automobile leaf springs' in 2009. In this work, the origin of premature fracture in leaf springs, used in Venezuelan buses, is studied. To this end, common failure analysis procedures, including examining the leaf spring history, visual inspection of fractured specimens, characterization of various properties and simulation tests on real components, were used. It is concluded that fracture occurred by a mechanism of mechanical fatigue, initiated at the region of the central hole, which suffered the highest tensile stress levels. Several factors (poor design, low quality material and defected fabrication) have combined to facilitate failure. Preventive measures to lengthen the service life of leaf springs are suggested.

G Harinath Gowd and E Venugopal Goud has presented Static Analysis of Leaf Spring in 2012 In Their work, leaf spring is modeled and static analysis is carried out by using ANSYS software and it is concluded that for the given specifications of the leaf spring, the maximum safe load is 7700N. It is observed that the maximum stress is developed at the inner side of the eye sections, so auther suggested that in eye design and fabrication and material selection. The selected material must have good ductility, resilience and toughness to avoid sudden fracture for providing safety and comfort to the occupants.

Mr. V. K. Aher , Mr. P. M. Sonawane Static And Fatigue Analysis of Multi Leaf Spring Used In The Suspension System Of LCV (2012) The fatigue life prediction is performed based on finite element analysis and fatigue life simulation method. FEM gives the prediction of critical area from the viewpoint of static loading. The results of non- linear static analysis of 2D model of the leaf spring using the commercial solver and analytical results shows better correlation. The stiffness of the leaf spring is studied by plotting load versus deflection curve for whole working load range which shows the linear relationship. Using the constant amplitude loading, the fatigue damage and life of the spring has been predicted. From the damage contour, the highest damage value is in acceptable range. This study will help to understand more the behavior of the spring and give information for the manufacturer to improve the fatigue life of the spring using CAE tools. It can help to reduce cost and times in research and development of new product.

Santosh Krishnaji Sinde e tal Static, Modal and Fatigue Life Prediction through CAE for a Leaf Spring used in Light Commercial Vehicle (2014)

Above work describes static, modal and fatigue analysis of a existing leaf spring and modifying existing steel leaf spring by reducing no of graduated leaves and increasing thickness. The dimensions of a modified leaf spring of a LCV are taken and are verified by design

calculations. . At 5kN load the deflection value and bending stress value for existing leaf spring from simulation are 102.43mm and 543.03N/mm2 respectively. .At 10kN load the deflection value and bending stress value for existing leaf spring from simulation are204.85mm and 1086.06N/mm2 respectively. At 5kN load the deflection value and bending stress value for modified leaf spring from simulation are 71.61mm and 523.70N/mm2 respectively. At 10kN load the deflection value and bending stress value for modified leaf spring from simulation are 143.23mm and 1047.35N/mm2 respectively.

All analytically calculated values of deflection and stresses are closely matching with values obtained from non-linear static stress analysis. From modal analysis it was found that the fundamental bending mode frequency of existing leaf spring is 8.80Hz and for modified leaf spring 10.68Hz. From fatigue simulation the minimum life of existing leaf spring was 3.94×105 cycles and for modified leaf spring 1.47×107 cycles.

Sarika S Yede and M.J Shaikh worked on Modeling and Finite Element Analysis of Leaf Spring in their work involves design and analysis of a conventional leaf spring under static and dynamic loading conditions. The 3D model is prepared in Creo 1.0, and then analysis is performed in the ANSYS 11.0 by considering same load in static and dynamic loading. For the cost reduction in existing leaf spring modification carried out by iteration method considering three cases such as varying number of leaves, varying width and varying thickness. The optimization has been carried out to satisfy the permissible value of factor of safety. The results are verified by comparison of Analytical and Finite Element Method. All analytically calculated values of deflection and stresses are closely matching with values obtained from ANSYS software. From the preliminary study it is concluded that from the comparison of materials Eglass /epoxy material is better than composite material & EN-45 Steel. And in comparison of shapes parabolic spring is better than conventional & elliptical leaf spring. Their project is in progress. Further it is decided to develop the CAD model of Leaf Spring. and to carry out Modeling by using Pro-E & analysis is carried out by using ANSYS Software by applying boundary conditions, & considering Stresses acting on leaf Spring & meshing on each component.

V.K.Aher, R.A.Gujar, J.P.Wagh & P.M.Sonawane presented Fatigue Life Prediction of Multi Leaf Spring used in the Suspension System of Light Commercial Vehicle (2012)

This work describes static and fatigue analysis of a steel leaf spring of a light commercial vehicle (LCV).

The dimensions of the leaf spring of a LCV are taken and are verified by design calculations. The non-linear static analysis of 2D model of the leaf spring is performed using NASTRAN solver and compared with analytical results.

The preprocessing of the model is done by using HYPERMESH software. The stiffness of the leaf spring is studied by plotting load versus deflection curve for various load applications. The simulation results are compared with analytical results. The fatigue life of the leaf spring is predicted using MSC Fatigue software.

Y.S. Kong , M.Z. Omar, L.B. Chua,S. Abdullah presented paper on Fatigue life prediction of parabolic leaf spring under various road conditions (2014) This paper serves to simulate the fatigue life of a parabolic leaf spring designunder variable amplitude loading (VAL). VALs carry the road signal that provokes fatigue failure on leaf spring. In order to seek for comprehensive leaf spring fatigue assessment, VALs signal were gathered through measurements from various road conditions such as highway, curve mountain road and rough rural area road. Subsequently, fatigue life of particular leaf spring design was predicted using finite element (FE) stress–strain model together with VALs signal as load input. For more conservative way, Morrow and Smith Watson Topper (SWT) mean stress correction methods were also applied. The results indicate that fatigue life of leaf spring is lowest during rough road mission, followed by curve mountain road and smooth highway road respectively. Additional design modification to prolong the fatigue life of the parabolic leaf spring is compulsory. The road VALs has provided even more realistic fatigue life estimation of parabolic leaf spring design when compared to traditional controlled laboratory method. Fatigue life predictions of parabolic leaf spring on smooth highway, curve mountain road and rough rural area road were presented. FE model together with VAL was used as the input to the fatigue life and damage simulation. FE method has provided the critical region of the parabolic leaf spring where the strain gauge was attached. Strain signal represents the parabolic leaf spring loading history when the bus travels on the particular road. Through this analysis, prediction of actual leaf spring life based on various road conditions was obtained where it could never be predicted in lab condition.

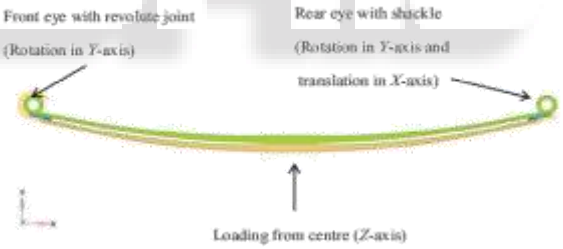

Fig. 2: Parabolic leaf spring boundary conditions.

Based on the simulation result, rural area rough road condition contributed highest damage to the parabolic leaf spring followed by curve mountain road and smooth highway road. Therefore, life of parabolic spring during rough road operations is lowest, and the second is mountain road condition. Smooth highway consists of highest life compared to others. Parabolic leaf spring redesign is required to be reconsidered when the bus is used for curve and rough roads. During the fatigue simulation, both Morrow and SWT model was adopted to estimate the fatigue life in more conservative way.

With the simulation results, description of fatigue behavior under various road terrains is possible and when bus usage in particular environment is known, the duration for parabolic leaf spring to fail in fatigue could be estimated.

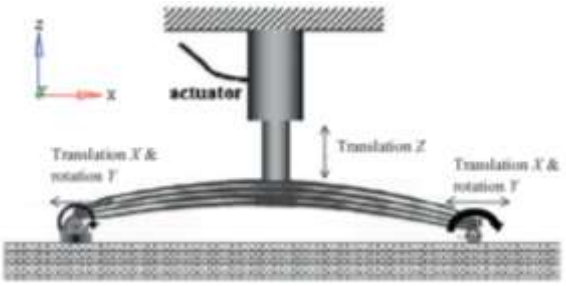

Fig. 3: Illustration of leaf spring experimental vertical stiffness test setup.

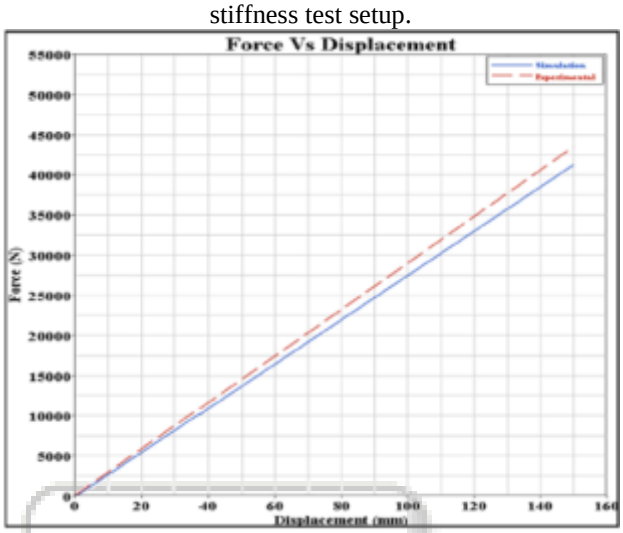

Fig. 4: Comparison of simulation versus experimental spring stiffness.

Basaran Ozmena,Berkuk Altiokb, Alper Guzelb, Ibrahim Kocyigitb, Serter Atamera

A novel methodology with testing and simulation for the durability of leaf springs based on measured load collectives (2015) In this study, the aim is to present the newly developed testing and simulation method for the durability of leaf springs in order to direct designers in the product development phase. The load spectra, which contain the variable amplitude loading to determine the fatigue life, were measured from different vehicles on rough road testing track. Afterwards, accelerated spectra were generated for testing and used in newly built fatigue test bench. Also, Finite Element Method (FEM) and Multi Body Simulation (MBS) calculations were performed and load spectra were processed with multichannel fatigue life calculation to generate a virtual test rig. This study illustrates a complete development process with the cooperation of testing and simulation departments to build a durability assessment method of leaf springs based on accelerated fatigue life testing using variable amplitude loading. The following statements can be concluded from this project:

Forces, displacements and strains on various leaf springs were measured from different vehicles on the rough road track in order to obtain the load spectra for the development of testing method. This load collective contains the variable amplitude loading which determines the fatigue life of the structure. Measured load spectra were processed by analyzing all of the collected signals in the time and frequency domain. Herewith, the total aimed damage and the percentage of each track in the aimed damage were evaluated. Then, the test signals, which can give the aimed damage within the accelerated time, were generated. These test signals were used in the newly built test bench and damages in this test bench were validated with strain measurements on the leaf springs. At the end, these determination of test signals were repeated for other leaf springs to complete the testing method for the all types.

IV. CONCLUSION

Several papers were devoted to analyze the various stresses produced in leaf spring by using FEM method. To overcome the failure of leaf spring they suggest composite material and special surface treatment. There is scope to analyze the stresses by using FEM as well as experimental method and suggest modification in existing leaf spring to reduce stress developed in leaf spring.

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