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DESIGN AND OPTIMIZATION OF LEAF SPRING BY USING FEA PACKAGES

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ABSTRACT

Leaf spring is a simple form of spring, commonly used for the suspension in wheeled vehicles. Leaf Springs are long and narrow plates attached to the frame of a trailer that rest above or below the trailer's axle. There are mono leaf springs, or single-leaf springs, that consist of simply one plate of spring steel. These are usually thick in the middle and taper out toward the end, and they don't typically offer too much strength and suspension for towed vehicles. Drivers looking to tow heavier loads typically use multi leaf springs, which consist of several leaf springs of varying length stacked on top of each other. The shorter the leaf spring, the closer to the bottom it will be, giving it the same semielliptical shape a single leaf spring gets from being thicker in the middle. The objective of this paper is to Predict the fatigue life cycle for crack initiation at maximum stress location in the Leaf spring.. The design constraints are stresses and deflections. The aim of this project is to study various parameters of leaf spring like Span length, thickness, number of leafs for existing semi elliptic leaf spring to minimize the overall weight of the assembly without hampering its structural strength. It also involves geometrical and finite element modeling of existing design and optimized design. Geometrical modeling is carried out by using CATIA V5 R -19 and finite modeling in ANSYS 17.0. Results of Static, and fatigue analysis of existing design and optimized design are compared.

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I. INTRODUCTION

We now live in a world that is varying and rising at persistent rate. Each new day we are presented with modern inventions which are two steps advance than the previous. Feasibility and effective techniques are the major keywords. Ideas of new minds has directed to the progress of newest and wanted technologies in the world of manufacturing. During service, any vehicle is subjected to loads that cause stresses, vibrations and noise in the different components of its structure. This requires appropriate strength, stiffness and fatigue properties of the components to be able to stand these loads. On top of that, quality of a vehicle, as a system, which include efficient energy Consumption, safety and provision of comfort to the user are highly desired. Vehicle dynamics, a discipline of broader significance, is an area where the basics of analyses on vehicles are dealt with. Forces/loads acting on vehicles can be categorized as road and gravity loads. Of all these forces and moments generated by tires at the ground are significant in controlling motion of the vehicle. The response of the vehicle structures to these loads are dealt with in vehicle dynamics. Different researches have been carried out regarding the performance, the response of components to static and dynamic loads, crashworthiness, safety and others by different institutions and automotive companies. Particularly, with the growing simulation capability using computers, researches are facilitated which are aimed to achieving better quality products. Parabolic leaf spring are the components of the

suspension system, they perform isolation task in transferring vibration due to road irregularities to driver's body. Increasing competition and innovations in automobile sector, tends to modify the existing products and replacing old products by new and advanced material products, more efforts are taken in order to increase the comfort of user, to improve the suspension system and hence many modifications have taken place over the time. Inventions of parabolic leaf spring and use of composite materials, for these springs are some of the latest modifications in suspension system. The main advantages of parabolic leaf springs are that they are lighter, cheaper and have better fatigue life. And they isolate more noise. CAE tools are widely used in the automobile industries for modelling.

II. LITERATURE SURVEY

[1] By Mohammed I. Hameed, Dhia A. Alazawi, Zaid S. Hammoudi (Finite Element Analysis of Steel and Composite Leaf Springs Under Static Loading)

In this work, the design and analysis have been performed for both of the steel and composite leaf springs. The stresses and deflection for the composite leaf spring are compared to those produced in the steel leaf spring. The considered composite materials in the design of mono composite leaf spring have been selected to be E-glass-Epoxy, Carbon - Epoxy, and Boron-Aluminum composites against the conventional 55si2Mn90 steel. The finite element method (FEM) has been employed to calculate the deflection and von-mises stresses for the springs by using the ansys 15.0 software. The results show that the leaf springs which are made of the light composite materials are as efficient as heavy steel springs. In comparison with the steel, a considerable weight reduction of 92%, 89% and 85% have been obtained for the Carbon-Epoxy, Boron-aluminium and Glass-Epoxy respectively. From the conducted results in this research work it can be concluded that the deflections in composite leaf springs are greater than that of the steel leaf spring and it is below the permissible design value as well. The minimum value of the stress has been observed in the glass epoxy composite leaf spring. The glass-epoxy composite material found to be appropriate in the manufacturing of a leaf spring for a light weight vehicles.

[2] By Zheng Yinhuan, Xue Ka, Huang Zhigao (Finite Element Analysis of Composite Leaf Spring)

This paper analyses the mechanics characteristic of a composite leaf spring made from glass fiber reinforced plastics using the ANSYS software. Considering interleaf contact, the stress distribution and deformation are obtained. Taking the single spring as an example, comparison between the performance of the GFRP and the steel spring is presented. The comparison results show that the composite spring has lower stresses and much lower weight. Then the automotive dead weight is reduced observably.

This paper analyses the mechanics characteristic of a composite leaf spring. Taking the single spring as an example, comparison between the performance of the GFRP and the steel spring is presented. The calculation results show that it can get the deformation of composite leaf spring and stress distribution of each leaf precisely through the finite element analysis. The results show that the stress of composite leaf spring is lower than steel spring and its resistance to fatigue ability is much stronger. In the case of meeting the strength requirements, it can greatly reduce the weight of leaf spring so that it will reduce the deadweight of vehicle. It meets the requirements of lightweight, comfort, stability and durability.

[3] By Thippesh L (Fabrication of Hybrid Composite Mono-Leaf Spring with Unidirectional Glass Fibers)

One of the vital parts during the design of an automobile is the Suspension system. The primary function of the suspension system is to minimize the transmission of road shocks. The role of composites in weight reduction and fuel saving in automobiles is highly significant. A combination of better material and better design approach will further enhance the weight reduction process. In the present work, multi leaf steel spring is replaced by the optimally designed composite mono leaf spring. A mono composite leaf Spring of unidirectional glass fiber reinforced plastic with similar mechanical and geometrical properties to the multi leaf steel spring, was fabricated and tested for static strength. The objective was to obtain a spring with minimum weight that is capable of carrying external forces without failure. Compare to steel springs, the composite spring has stresses that are much lower, the natural frequency is higher and the spring weight is reduced considerably. From this research work he conclude that The deflection and maximum stress obtained for composite leaf springs experimentally have good agreement with steel leaf spring. Composite leaf spring reduces the weight by 80% for E-Glass/Epoxy compared to steel leaf spring. From the experimental results, it is observed that the stresses and deflections in integrated composite leaf spring are less compared to steel leaf spring. The composite mono composite leaf spring gives better performance and brings greater efficiency of the vehicle compared to steel leaf spring. Here the composite mono leaf spring could be replaced for the conventional steel leaf spring.

[4] Harmeet Singha, Gurinder Singh Brarb (Design and Analysis of Leaf Spring using Various Composites –An Overview)

This paper deals with the characterization and mechanical properties of composite materials that can be used for the leaf spring. Aluminum based metal matrix and carbon epoxy composite materials have been used in various industries including automobile industry because of their light weight and good strength. In this present study rear leaf spring of Tata Ace (mini truck) made of EN45A spring steel has been considered. Metal Matrix Composite (MMC) leaf spring with Aluminum and 25% boron carbide manufactured by stir casting technique and carbon epoxy based leaf spring manufactured by hand layup fabrication technique were investigated for use in leaf spring. Both composite based leaf spring were examined under tensile stress and hardness test as per the standards – IS 1135: 1995

(Laminated Springs Assembly for Automobiles) and SAE (HS - J788 - Manual on Design and Application of Laminated Springs). The evaluation of EN45 steel and both composite based leaf spring shows that the composite spring has the low density, low weight and high strength. From the experimental results the strength of both composite materials matched with the properties of EN45 steel leaf spring and also it was found that by increasing the weight fraction and dimension will increase the strength and hardness of the specimen. Results show that 7075 Al reinforced with 25% B4C and carbon epoxy composite were successfully produced via stir casting method and hand layup technique. The composite leaf spring is lighter in weight as compared to conventional steel leaf spring with similar design specification.

[5] K.Ashwini a, Prof C.V. Mohan Rao (Optimization of Various Design Parameters for EN45A Flat Leaf Spring)

This review is designed to be a comprehensive source for designing a leaf spring using various composites as the Automobile industries are showing keen interest for replacing steel leaf spring with that of a composite leaf spring to obtain reduction in weight, which is an effective measure for energy conservation as it reduces overall fuel consumption of the vehicle. This review provides a brief summary on the work carried out for designing and analyses of composite leaf spring. Many of the authors suggested various methods of designing, manufacturing and analyses of composite leaf spring to reduce the overall weight and increase strength of the leaf spring. For this, various composite materials were used. Static, Fatigue and Modal analysis were performed using experimental and analytical methods.

III. PROBLEM STATEMENT

Automotive sector is fuel economy and emissions due to this the automotive designers are revisiting automotive systems and parts for reducing the weight of the vehicles.

For suspension systems, leaf spring is one of the key targets for weight since it adds onto the un sprung mass which affects the ride of the vehicle. The Problem is that load carrying capacity, stresses, deflection and weight of Structural steel leaf spring. A leaf spring made of structural steel. Stresses, deflection, weight.

IV. OBJECTIVES

- To prevent the road shocks from being transmitted to the vehicle components.
- To safeguard the occupants from road shocks.
- To preserve the stability of the vehicle in pitting or rolling, while in motion.

V. APPLICATION

The leaf springs are widely used in suspension system of railway carriages and automobiles. But the form in which it is normally seen is laminated leaf spring.

VI. LEAF SPRING DETAILS

The suspension leaf spring is one of the potential items for weight reduction in automobile as it accounts for ten to twenty percent of the unsprung weight. The introduction of composites helps in designing a better suspension system with better ride quality, if it can be achieved without much increase in cost and decrease in quality and reliability. In the design of springs, strain energy becomes the major factor. The relationship of the

Specific strain energy can be expressed

$$U = \frac{\sigma^2}{\rho E}$$

Where σ is the strength, ρ is the density and E is the Young's Modulus of the Spring material It can be easily observed that material having lower modulus and density will have a greater specific strain energy capacity .The introduction of composite materials made it possible to reduce the weight of the leaf spring without reduction of load carrying capacity and stiffness due to the following factors of composite materials as compared to steel. Arrangement of leaf spring in a car Model An upturned spring eye is used to attach the front end of semi-elliptic leaf spring to the chassis frame, and a free end with a bracket constraining vertical motion to attach the back end of semi-elliptic leaf spring to the chassis frame.

VII.METHODOLOGY

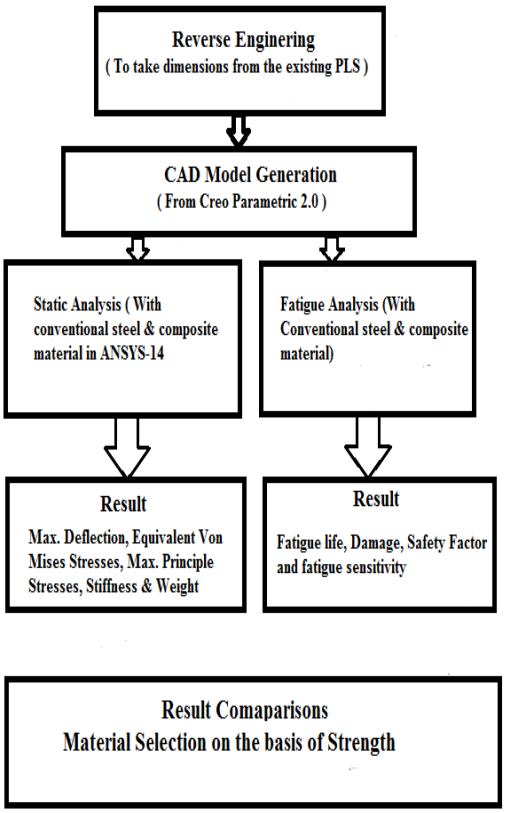

Fig 1. Propsoed block diagram

Proposed Setup:

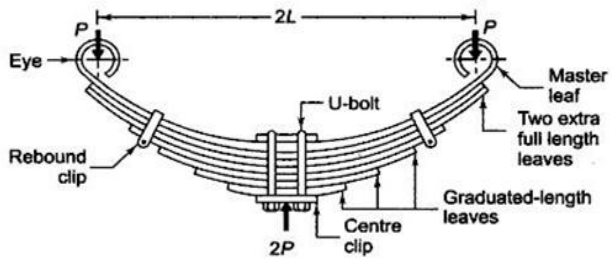

Fig 2. Propsoed setup model

VIII. CONCLUSION

To summarize, we have examined the meaning of modal analysis and various nomenclature. It is critical that a designer understands the natural vibration frequencies of a system in order to ensure that they are not the same as excitation frequencies, thus ensuring safety standards. This is a key component in many fields like civil, aerospace, or automotive engineering where loss of life and property is a major concern. Starting with hand calculations in the 1980s, computer simulations have made great breakthroughs to help improve the quality and robustness of design processes. We look forward to the day when computer simulations can replace engineering codes.

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