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A Review on Comparative Analysis of Leaf Spring by Using Different Variable Materials

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Abstract: **Reducing weight while increasing or maintaining strength of products is getting to be highly important research issue in this modern world. Composite materials are one of the material families which are attracting researchers and being solutions of such issue. In this paper we describe design and analysis of polymer composite leaf spring. The objective is to compare the stresses, deformations and weight saving of composite leaf spring with that of steel leaf spring. The Automobile Industry has great interest for replacement of steel leaf spring with that of composite leaf spring, since the composite materials has high strength to weight ratio and good corrosion resistance. The material selected was glass fibre reinforced polymer (E-glass/epoxy) and is used against conventional steel. The design parameters can be selected and analysed with the objective of minimizing weight of the composite leaf spring as compared to the steel leaf spring.**

Keywords: **composite leaf spring, epoxy, stiffness, ANSYS.**

I. Introduction

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. In the present scenario the main focus of automobile manufacturers is weight reduction of the automobile. Weight reduction can be achieved mainly by introducing the better material, design optimization and better manufacturing processes. Composite materials have made it possible to reduce the weight of leaf spring without any reduction in load carrying capacity and stiffness. Composite materials are now used extensively in place of metal parts. Several papers were devoted to the application of composite materials for automobiles. The figure shows a laminated semi- elliptic spring. The top leaf is known as the master leaf. The eye is provided for attaching the spring with another machine member. The amount of bend that is given to the spring from the central line, passing through the eyes, is known as camber. The camber is provided so that even at the maximum load the deflected spring should not touch the machine member to which it is attached. The central clamp is required to hold the leaves of the spring.

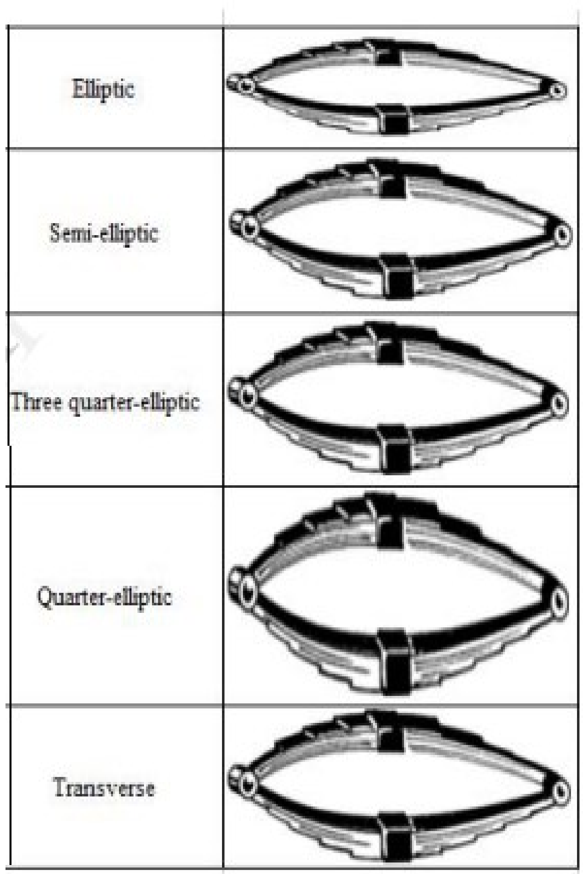

Fig. 1. Types of leaf spring

A leaf spring is a simple form of spring, commonly used for the suspension in heavy vehicles. It is also one of the oldest forms of suspension system. The advantage of leaf spring over helical spring is that the end of the springs may be guided along a definite path. The Centre 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 layer with progressively shorter leaves. Leaf springs can to some extent damping as well as springing functions. A leaf spring can either be attached directly to the frame at both ends or attached directly at one end, usually the front, with the other end attached through a shackle, a short swinging arm [1]. The shackle takes up the tendency of the leaf spring to elongate when compressed and thus makes for softer springing actions.

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 lengthiest blade has eyes on its ends [2]. This blade is called main or master leaf, the remaining blades are called graduated leaves. All the blades are bound together by means of steel straps. The spring is mounted on the axle of the vehicle. The entire vehicle load is rests on the leaf spring..

II. LITERATURE REVIEW

D. Lydia Mahanthi et al. [1] In this approach by introducing composite materials into automobile industries, which is having low cost, high strength to weight ratio and excellent corrosive resistance can fulfill the requirement. The suspension leaf spring is one of the potential entities for weight reduction in automobiles as it results in large unstrung mass. The introduction of fiber reinforced plastics (FRP) is used to reduce the weight of the product without any reduction on load carrying capacity and spring rate. As the materials high strain energy storage capacity and high strength-toweight ratio compared to steel, multi-leaf springs are being replaced by mono-leaf FRP spring.FRP springs also have excellent fatigue resistance and durability.

V.Prabhu et al. [2] in this paper presented of this system results to better vibration energy absorption within the material and results in reduced transmission of noise and vibration to neighboring structures. High damping capacity of composite materials can be beneficial in many aerospace, automotive applications in which noise, vibration, strength and hardness is a critical issue for passenger comfort. Among the other environmental factors that may cause degradation in some of the mechanical properties of some polymeric matrix composites are elevated temperatures, corrosive fluids, and ultraviolet rays. In many metal matrix composites, oxidation of the matrix well as adverse chemical reaction between fibers and matrix are of great concern at high temperature applications.

S Jebarose Juliyana et al. [3] The purpose of the work is, to analyze Unidirectional Glass Fiber/Epoxy mono composite leaf spring, for replacing the steel leaf spring by fiberglass composite leaf spring in automotives, by decreasing the weight and increasing the strength. A mono composite leaf spring with varying thickness, varying width design was analyzed for static linear and modal analysis. The FEA results showing stresses, deflections and natural frequency were verified with previous experimental results.

Mehul Sorathiya et al. [4] The paper describes a static analysis of steel leaf spring and laminated composite leaf spring. The dimensions have been taken of an existing conventional steel leaf spring for Light vehicle mini truck. Static Analysis of a 3-D model of conventional leaf spring is performed using finite element analysis (FEA). Same dimensions are used in composite multi leaf spring using carbon/Epoxy and Graphite/Epoxy unidirectional laminates. The load carrying capacity, and mass of composite leaf spring are compared with that of steel leaf spring. The design constraints are stresses and deflection. A weight reduction of 80 % is achieved by using composite leaf spring. And if mono leaf spring has been considered then mass reduction has been achieved 90 %. The fatigue life is also calculated using analytically as well as using ANSYS for leaf spring. The natural frequency and mode shapes are determined using modal analysis.

Raghu Kumar et al. [5] In the present scenario, composites are widely used in most of the industries in place of steel, due to low weight to strength ratio. In automobile industry, one can think of replacing parts with composites. The aim of this paper is to suggest the best composite material for design and fabrication of complete mono composite leaf spring. A single leaf with variable thickness and variable width for constant cross sectional area of different composite materials, with similar mechanical and geometrical properties to the multi leaf spring, were modeled and analyzed. The finite element results using ANSYS software showing stresses and deflections were verified with analytical results. The design constraints were stresses and displacement. Compared to the steel spring, the composite spring has stresses and deflection that are much lower, and the spring weight is nearly 78% lower.

Pulkit Solanki et al. [6] In this paper we would like to review some previous research work performed on the leaf spring by previous researchers for increasing the working condition and capacity with load reduction. The paper based on material composition, experimental testing and load (Steady, Dynamic) study etc.

Prahalad Sawant Badkar et al. [7] worked on Design improvements of leaf Spring of BEML Tatra 815 VVNC 8 X 8 Truck. Main objective of this work is increase the PL carrying capacity of BEML Tatra by 5000 kg. by incorporating the necessary changes in suspension system(Leaf Spring) of the vehicle. The distribution of gross vehicle weight (GVW) on the front and rear tandem axles are Front axle weight is 2 x 6500 kg, Rear axle weight is 2 x 7500 kg, Gross vehicle weight is 28,000 kg . Here they do some changes in design so they distributed weight of of Fifth wheel load (FWL) on the front and rear tandem axle is Front axle weight is 2 x 6750 kg, Rear axle weight is 2 x 9750 kg ,Gross vehicle weight is 33,000 kg . The new design of rear leaf spring, stress vehicles for rated load and maximum load are well within the yield stress of material. The new design rear leaf spring also gives the higher fatigue life this is most important in design of any leaf spring, this helps in measure the life of spring. Results showed that finite element analysis (FEA) on rear leaf spring verifies that, design were adequate. The material 60Cr4V2 is better for design of new leaf spring, which fulfills the requirement.

III. VERTICAL LOADS

When the rear wheel comes across a bump or pit on the road, it is subjected to vertical forces, tensile or compressive depending upon the nature of the road irregularity. These are absorbed by the elastic compression, shear, bending or twisting of the spring. The mode of spring resistance depends upon the type and material of the spring used. Further when the front wheel strikes a bump it starts vibrating [8]. These vibrations die down exponentially due to damping present in the system. The rear wheel however, reaches the same bump after certain time depending on the wheel base and the speed of the vehicle. Of course, when rear wheel reaches the bump, it experiences similar vibrations as experienced by the front wheel some time ago. It is seen that to reduce pitching tendency of the vehicle, the frequency of the front springing system be less than that of the rear springing system.

A. Rolling

The centre of gravity of the vehicle is considerably above the ground. Due to this reason, while taking a turn, the centrifugal force acts outwards on the C.G of the vehicle, while the road resistance acts inward at the wheels. This gives rise to a couple turning the vehicle about a longitudinal axis. This is called rolling.

B. Brake-dip

On braking, the noise of the vehicle has a tendency to be lowered or to dip. This depends upon the position of centre of gravity relative to the ground, the wheelbase, and other suspension [9]. In the characteristics the same way, torque loads during acceleration end the front of the vehicle to be lifted. These forces on account of braking and driving are carried directly by deflecting the springs, by wishbone arms.

C. Side thrust

Centrifugal force during cornering, cross-winds, cambering of the road etc., cause a side-thrust to be applied to the vehicle, such forces are usually absorbed by the rigidity of the leaf springs.

D. Unsprung weight:

Un-sprung weight is the weight of vehicle components between the suspension and then road surface. This includes rear axle assembly, steering knuckle, and front axle in case of rear drive rigid suspension, wheels, tires and brakes. The sprung weight i.e. the weight supported by the vehicle suspension system, includes the frame, body, engine, and the entire transmission system.

When the wheels strike against a bump, they vibrate along with other unsprung parts which store the energy of the vibrations and then further transmit it to the sprung parts via the springs. Thus it is seen that greater the weight of the unsprung parts, greater will be the energy stored due to vibrations and consequently greater shocks.

E. Fatigue

The term fatigue of materials and structural components means damage and damage due to cyclic, repeatedly applied stresses [10]. In material science, fatigue is the progressive, localized, and permanent structural damage that occurs when a material is subjected to cyclic or fluctuating strains at nominal stresses that have maximum values less than the static yield strength of the material. The resulting stress may be below the ultimate tensile stress, or even the yield stress of the material, yet still cause catastrophic failure.

F. Materials for leaf spring

The material used for leaf springs is usually a plain carbon steel having 0.90 to 1.0% carbon. The leaves are heat treated after the forming process. The heat treatment of spring steel products has greater strength and therefore greater load capacity, greater range of deflection and better fatigue properties.

G. Carbon/graphite fibers

Their advantages include high specific strength and modulus, low coefficient of thermal expansion and high fatigue strength. Graphite, when used alone has low impact resistance. Its drawbacks include high cost, low impact resistance and high electrical conductivity

Carbon steel Carbon steel, or plain-carbon steel, is a metal alloy. It is a combination of two elements, iron and carbon. Other elements are present in quantities too small to affect its properties. The only other elements allowed in plain-carbon steel are: manganese (1.65% max), silicon (0.60% max), and copper (0.60% max). Steel with low carbon content has the same properties as iron, soft but easily formed. As carbon content rises the metal becomes harder and stronger but less ductile and more difficult to weld.

IV. Composite Materials

A composite material is defined as a material composed of two or more constituents combined on a macroscopic scale by mechanical and chemical bonds. Composites are combinations of two materials in which one of the material is called the “matrix phase” is in the form of fibers, sheets, or particles and is embedded in the other material called the “reinforcing phase”. Many composite materials offer a combination of strength and modulus that are either comparable to or better than any rational metallic metals. Because of their low specific gravities, the strength to weight-ratio and modulus to weight-ratios of these composite materials are markedly superior to those of metallic materials.

The fatigue strength weight ratios as well as fatigue damage tolerances of many composite laminates are excellent. For these reasons, fiber composite have emerged as a major class of structural material and are either used or being considered as substitutions for metal in many weight-critical components in aerospace, automotive and other industries. Another unique characteristic of many fiber reinforced composites is their high internal damping capacity. This leads to better vibration energy absorption within the material and results in reduced transmission of noise to neighboring structures. High damping capacity of composite materials can be beneficial in many automotive applications in which noise, vibration, and hardness is a critical issue for passenger comfort.

V. Conclusion

The existing carbon steel material can be replaced with the composites without compromising the life, reliability, and performance of leaf spring. In this paper, the selection of different composite materials based on the requirement of properties of leaf spring is made. E-glass epoxy is better than using carbon steel as though stresses are a little bit higher than carbon steel, E-glass epoxy is having good yield strength value and also epoxy material components are easy to manufacture and thus having very low weight while comparing with traditional materials. Riding comfort and performance is improved due to a reduction in unsprang mass of the vehicle.

REFERENCES

[1] D. Lydia Mahanthi, C. Venkata Siva Murali "Design and analysis of composite Leaf Spring for light Weight Vehicle" International Journal of Advanced Engineering Research and Science (IJAERS), Vol-4, Issue-3, pp. 147-152, Mar- 2017.

[2] V.Prabhu, Researcher Ijar "DESIGN AND ANALYSIS OF COMPOSITE LEAF SPRING USING ANSYS" vol. 4 April 2017.

[3] S Jebarose Juliyana, J.Udaya Prakash "Finite element analysis of mono composite leaf spring of varying thickness and varying width used in automotives" DOI: 10.24247/ijmperddec201727, November 2017

[4] Mehul Sorathiya, Dhaval B Shah "Various Numerical Analysis of Composite Leaf Spring for Light Vehicle Mini Truck" DOI: 10.13140/2.1.2135.8080, November 2013.

[5] Raghu Kumar "Static analysis of mono leaf spring with different composite materials" DOI: 10.5897/ JMER 11.075, February 2013.

[6] Pulkit Solanki, Dr. Ajay Kumar Kaviti "Study and Review on the Analyses of Leaf Spring" International Journal for Scientific Research & Development| Vol. 3, Issue 09, 2015.

[7] Prahalad Sawant Badkar, Prahalad Sawant Badkar " Design Improvements of Leaf Spring of BEML Tatra 815 VVNC 8 X 8 Truck " International Journal of Emerging Technology and Advanced Engineering ,Volume 3, Issue 1, January 2013.

[8] Rajagopal D. Varun S., Manikanth M., BysaniSomasaiSriram Kumar; "Automobile Leaf Spring from Composite Materials," International Journal of Engineering and Advanced Technology (IJEAT), Oct 2014.

[9] Mohammed MathenullaShariff, N. SreenivasaBabu, Dr.JaithirthaRao; "Analysis of Glass Epoxy Reinforced Monolithic Leaf Spring," IJMER, 2014.

[10] Kumarkrishna and Aggarwal M.L.; "A Finite Element Approach For Analysis of a Multi Leaf Spring Using CAE Tools," Research Journal Of Recent Science, Feb 2012.