REVIEW ON DESIGN OPTIMIZATION AND ANALYSIS OF COMPOSITE LEAF SPRING FOR LIGHT WEIGHT VEHICLE

Mr. Mangesh Angadrao Bidve [1] Dr. Manish Billore [2]
[1] *Scholar, Department of Civil Engineering (Ph.D.), Oriental University, Indore (M.P), India*
[2] *Guides, Department of Civil Engineering (Ph.D.), Oriental University, Indore (M.P), India*

ABSTRACT

Leaf springs are commonly used in the suspension system of automobiles and are subjected to millions of varying stress cycles leading to fatigue failure. If the unspring weight (the weight, which is not supported by the suspension system)is reduced, then the fatigue stress induced in the leaf spring is also reduced. Leaf spring contributes for about 10-20% of unspringweight. Hence, even a small amount of weight reduction in the leaf spring will lead to improvements in passenger comfort as well as reduction in vehicle cost. In this context, the replacement of steel by composite material along with an optimum design will be a good contribution in the process of weight reduction of leaf springs. Different methods are in use for design optimization, most of which use mathematical programming techniques. This paper presents an ACO approach for the design optimization of composite leaf spring. On applying the ACO, the optimum dimensions of a composite leaf spring have been obtained, whichcontributes towards achieving the minimum weight with adequate strength and stiffness. A considerable reduction of weight is achieved when a seven-leaf spring is replaced with a mono-leaf composite spring under identical conditions of design parameters and optimization

Key Words: *Design Optimization, Analysis of Composite Leaf Spring, Light Weight Vehicle*

I. 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.

This part inspects the structure and re-enactment of leaf springs that basically withstand twisting. The leaf spring is the most widely recognized sort of composite spring. A leaf spring mounted a lengthways way has a wheel driving capacity, including retention of brake powers and parallel powers. A transverse leaf spring has a wheel managing capacity that directs the spring pace of the haggle suspension of a vehicle. A transversal leaf spring is exposed to two unique loads in the vehicle. From one viewpoint, it assumes control over the ordinary lifting suspension of the pivot, and then again, contingent upon the structure, it assumes control over a few or the entirety of the necessary move adjustment of the hub. The lifting suspension can be portrayed as a symmetrical burden, since the two wheels move a similar way. For basic kinds of leaf spring, advancement investigation is performed and the rule mechanical highlights are clarified.

The advantage of composite material is that, if well designed, they will give best qualities of these composites or constituents and often some qualities that neither constituent possesses. Some of the properties that can be improved by forming a composite material are: strength, stiffness, corrosion resistance, wears resistance, fatigue life, weight reduction, attractiveness, thermal conductivity, thermal insulation, acoustical insulation, temperature dependent behavior, etc. Fiber-reinforced polymers have been vigorously developed for many applications, mainly because of the potential for weight savings. Other advantages of using fiber-reinforced polymers instead of steel are: the possibility of reducing noise, vibrations and ride harshness due to their high damping factors; the absence of corrosion problems, which means lower maintenance costs; and lower tooling costs, which has favorable impact on the manufacturing costs.

A. MATERIALS FOR LEAF SPRING

The design of composite leaf spring aims at the replacement of seven-leaf steel spring of an automobile with a mono-leaf composite spring. The design requirements are taken to be identical to that of the steel leaf spring. The Input parameters for the
Design of a spring is shown in table 1.

- Design load, W = 4500 N,
- Maximum allowable vertical defection, dmax = 160 mm,
- Distance between eyes in straight condition, L = 1220 mm,
- Spring rate, K = 28-32 N/mm.

Table 1the input parameters considered for the design of leaf spring in both cases

Parameters	Steel Spring	Composite Spring
Spring Length ,mm	1220	1220
Arc Height (Camber) ,mm	160	160
Modulus of Elasticity , N/mm^2	210 E^2	32.5 E^2
Material Density , Kg/m^3	7800	2600
Load	4500	4500
Maximum allowable Stress , MPa	800	550

II. LITERATURE SURVEY

Vikas Khatkaret. al. TSRC were analysed for mechanical properties like tensile strength, flexural strength (3 point bending), Izod impact strength. Further damping and wear behaviour were also investigated to know their applicability as leaf spring material. Mechanical performance of 3D woven based composite leaf spring were found significantly better than chopped, UD and 2D counterparts with regard to delamination, impact strength and improved storage modulus. 3D composite leaf spring showed high potential for automotive leaf spring applications. [1]

T.G. Loganathanet. al. Automobile Leaf spring is the component supports vehicle dynamics, in turn travel comfort by offering required stiffness. In this work, automobile leaf spring is the focus of study in terms of material change from the conventional SAE 5160 steel (Chromium steel) to CFRP (Carbon Reinforced Polymer Composite) to have a considerable strength, associated weight reduction with minimized fuel consumption and increases the performance of the vehicle.. The present work provides the results of flexural fatigue life and damage incurred for both the material by FE Analysis. In order to obtain the better results of fatigue life of composite materials, various ply orientations are also considered. [2]

Rama Krishna Reddy Guduruet. al. The mechanical residences of a leaf spring depend on the type of material, Fabrication methods, and fiber orientation used. Some unique composite materials have higher stiffness and greater pressure rate as associated with metals, the strength of composite material additionally depends on the geometry and shape. In this paper, the mechanical properties of different composite materials are examined to find out the greatest suitable composite fabric for the fabrication of a mono composite leaf spring. Overall weight, stiffness, and load-carrying capability of the fabricated leaf spring were determined using distinctive experimental tests. The experimental results show a weight reduction of 69.4% and 75% respectively for the aid of the usage of glass fiber epoxy and Carbon fiber. [3]

K.Ashwiniet. al. a Suspension system of a vehicle is an area where innovations are carried out regularly. Reduction in weight can be achieved by introducing better material, design optimization and improved manufacturing processes. The suspension leaf spring is one of the potential items for weight reduction in automobiles as it accounts for 10-20% of the unsprung weight. The composite material offers opportunities for substantial weight saving without compromising on load carrying capacity and stiffness. Many composite materials offer a combination of maximum strength and minimum modulus of elasticity in the longitudinal direction which is the most suitable material for a 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. [4]

Jun Keet. al. Its design method and performance investigation are the research hotspots in the application field of composite structures. This paper presents an overview of research results on the material selection, the design method of the joint and the spring body of composite leaf springs, including stiffness calculation method and optimization method. This article also gives an overview of performance investigation results reported in the literature for the modal, damping, and dynamic stiffness, response to low frequency impact, creep behaviour, fatigue performance and loading performance of composite leaf springs. Finally, the emerging trends in the research of composite leaf springs are summarized. The design method of the joint and the spring body of composite leaf springs, including stiffness calculation method and optimization method. [5]

T. Keerthi vasanet. al. Normal leaf spring may leads to failure due to leaf spring disappointment which leads to accident. Leaf springs, oldest forms of suspension system used in automobiles. The behavior of the automobile systems is based on performance of leaf spring. Heavy weight of leaf spring is considered as drawback. To avoid this, researchers pointed out in reducing weight of leaf spring with the help of alternate materials. Objective of this paper is to reduce weight of leaf spring by using composite materials like Glass, carbon, Aramid fibers and Epoxy resin. The different specimens were prepared using Manual layup method, they are taken for Flexural, tensile and Impact test. All values are tabulated and compared. The composite leaf spring will provide better performance when compared to ordinary steel leaf spring. So selection of composite materials for the manufacturing of leaf spring will provide better efficiency. [6]

Memnon, Y et. al. Full-scale lateral load tests were performed at a site in Brittany, France on a 6-pile groups well as a single pile. The pile group was composed of six piles hinged in a rigid cap and aligned in two rows spaced three pile diameters apart center-to-

center. The three- pile diameter spacing resulted in pile-soil interaction, which reduced the soil resistance.
Brown, D.A.et. al. A lateral load test was conducted on a group of nine piles. The deflection in the group was significantly greater than the deflection of the single pile. As the load increased the group effect increased. At large loads, the "group effect" was significantly more apparent and a "collapse" load was more apparent.

Rollins, K. M.et. alconducted a full-scale static lateral load test of a 3 X 3 pile group at the Salt Lake City International Airport. The group deflected 2 to 2.5 times as much as the single pile under the same average per pile loading. In contrast to previous tests, Rollins et al found that the backrow carried a greater load than the middle row. A difference in pore water pressures seems to be the explanation for the increased load carrying capability of the back row. The load per pile was always less than that of the single piles for equivalent deflections due to the group effect.

Donavan, T.W.et. al. The Boundary Element Method (BEM) approach was developed for the analysis of pile groups. The proposed BEM method saves computational effort compared to more sophisticated codes such as VERSAT-P3D, PLAXIS 3D and FLAC-3D.

III. OBJECTIVES OF PROPOSED RESEARCH WORK

The research described in this report had the following objectives:

1. To Design Optimization and Analysis of Composite Leaf Spring for Light Weight Vehicle.
2. To propose comparison of conventional mono and multi steel leaf spring, composite leaf spring have less weight, stresses, vibration and increasing strength, fatigue life and ride comfort.
3. To develop the design theory of composite leaf springs which will enhance their applications in automobile industry and other mechanical systems
4. To study Involvement and placement of rubber pads on the inside surfaces of the blades to cushion bottoming out of the springs. This will reduce the impact load transferred to the chassis in the event that the suspension reaches full deflection.
5. To study joint of the spring to the vehicle body, an additional lay-up was used on the spring end and the steel eyes were mounted through bolts.

IV. CONCLUSION

This paper focuses only on the literature review of previously published studies. The finding of this paper isright now structure of leaf spring back suspension for back motor talked about. This is nontraditional sort of suspension with leaf spring application for back motor vehicle. Generally, for light business vehicles, Engine is put at front/center giving immense space for customary back pivot with differential inside. Structure of back suspension is confirmed and approved effectively for solidness and taking care of by doing limited component investigation and testing. Plan and assembling of an utilitarian composite spring for a sun based controlled light vehicle is portrayed. The goal is to give a comprehension of the production, use, and capacities of composite leaf springs created by utilizing unidirectional Eglass' meandering impregnated by an epoxy gum for light vehicle applications where the vehicle weight is of essential concern. The present plan application includes a sunlight based fueled vehicle

V. REFERENCES

1. *Vikas Khatkar et. al. "Textile structural composites for automotive leaf spring application" Science Direct 28 November 2019*
2. *T.G. Loganathan et. al. "Flexural and fatigue of a composite leaf spring using finite element analysis" Science Direct 24 November 2019*
3. *Rama Krishna Reddy Guduru et. al. "Development of mono leaf spring with composite material and investigating its mechanical properties" Elsevier 12 February 2020*
4. *K.Ashwini et. al. "Design and Analysis of Leaf Spring using Various Composites – An Overview" science direct (2018)*
5. *Jun Ke et. al. "A review on material selection, design method and performance investigation of composite leaf springs" science direct 26 July 2019*
6. *T. Keerthi vasan et. al. "Fabrication and testing of composite leaf spring using carbon, glass and aramid fiber" Science Direct 30 May 2019*
7. *Erol Sancaktar et. al. "Design, analysis, and optimization of composite leaf springs for light vehicle applications" Elsevier 1999*
8. *Mahmood M. Shokrieh et. al. "Analysis and optimization of a composite leaf spring" 2003 Elsevier Science Ltd.*
9. *Thippesh L "Fabrication of Hybrid Composite Mono-Leaf Spring with Unidirectional Glass Fibers" Elsevier Science Ltd. (ICAMA 2016).*
10. *Darshan Kapadia et. al. "Design And Analysis Of Composite Leaf Spring For Light*
11. *Weight Vehicle" IJESRT June, 2016*
12. *Naman Gupta et. al. "Design, Analysis and Weight Optimization of leaf spring for light weight vehicle" (IRJET) Volume: 05 Issue: 01 | Jan-2018*
13. *Kiran. K. Jadhao " Size Optimization of Composite Leaf Spring for Light Commercial Vehicle" (IJETT) – Volume 51 Number 1 September 2017*