

A Review on Composite Leaf Spring

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Abstract : Conveyance is the most consequential need in today's life. Sundry types of conveyances are now a day's utilized by us in our day to day life. Every conveyance requires a suspension system for uneven vibration isolation. Most of the cumbersome hefty conveyances like trucks and busses use leaf spring as a suspension system. Even some of the light obligation conveyances additionally use leaf spring as a rear-wheel suspension system. Now a day's research is going on to abbreviate the weight of this leaf springs as the conventional leaf spring is composed of steel which is quite heftily ponderous. To do so composite material leaf springs are being designed now a day as composites are much more salutary over conventional steel. In this review, we are going to discuss sundry researches going on composite leaf springs and advantages of composite leaf spring over conventional leaf spring.

IndexTerms - Leaf spring, suspension system, vibration isolation, heavy vehicles.

I. INTRODUCTION

Conveyance is the rudimental desideratum of mankind in today's world. Sundry betokens of conveyance are utilized by humans are road convey, areal convey and water convey. Out of these roads convey is utilized more often. In road convey sundry types of conveyances are available and in this conveyances, one prevalent quandary is incorporated which is the transfer of vibration from the road to wheels and then from wheels to other components of the conveyance. These dispensable vibrations can lead to conveyance failure. To eschew this vibration transfer in the conveyance vibration isolators are utilized such as suspension system. Most of the heftily ponderous conveyances use a leaf spring suspension system as a vibration isolator.

The weight of the conveyance is the most paramount factor as it increments the fuel consumption. Most of the innovation is now a day's being done to minimize the weight of the conveyance. Truncation in weight can be achieved by utilizing better material in lieu of utilizing conventional material. Weight truncation can be done in sundry components of the conveyance out of which suspension system is one of the components of the conveyance in which a lot of research is being carried out. Concretely conventional leaf springs are the potential item if we consider weight minimization in conveyances. Utilization of composite material can substantially truncate the weight without perturbing the loading capacity of the conveyance. Many composite materials are available which offer high vigor to weight ratio. This type of materials can prosperously supersede the utilization of conventional steel in leaf spring suspensions [1].

Composites are now a day's becoming an emerging trend in the field of mechanical engineering because of their number of advantages. Springs are the most crucial part of the suspension system. Springs are responsible to minimize the vertical vibrations, bumps, and impacts because of eccentric roads and additionally amend the comfort in the conveyance. Leaf spring is one of the types of spring in the suspension system. Longitudinal type leaf spring is a very reliable element of suspension system in the automobiles. Leaf spring is composed of several longitudinal steel plates stacked over one another in incrementing longer lengths on top of each leaf. Which makes the leaf thicker in the middle to resist bending and thinner at the terminus where it is connected to the chassis. The most consequential work of leaf spring is to resist the variable vertical forces. This vertical vibrations and impacts are absorbed by the spring deflection and then stored in the form of potential energy in spring and relinquished gradually. As the leaf spring firstly stores energy hence it is indispensable to increment the energy storage capacity of the leaf spring which will make the system more compliant. This energy storage can be affected by the type of material used to make leaf spring and cross-sectional area of the leaf. Generally, steel leaves are habituated to make leaf spring in the automobile industries. Now a day's most of the researchers are designing the leaf springs of composite materials which have sundry advantages over steel. One of the most salutary reasons for considering composites instead of steel is their weight. Other paramount characteristics of the composites are high vigor to weight ratio, less friction between two leaves, more fatigue vigor, non-corrosive nature, high natural frequency, etc.[2]

II. TYPES OF LEAF SPRING

There are a variety of leaf springs generally employed in automobiles. The commonly used leaf spring is 'Elliptical' or 'full elliptical' leaf springs, the name of this spring itself suggests it is elliptical in shape. In this type of spring, two semi-elliptical leaf springs are affixed to each other composing the shape of an ellipse. In this type of leaf springs, the top center is connected to the frame and the lower bottom center is connected to the axel of the wheel. The figure of this spring is shown in figure 1.[3]



Fig. 1. Elliptical leaf spring

If we consider only the bottom a moiety of the elliptical leaf spring then that type of leaf spring is denominated as 'semi-elliptical leaf spring'. This type of leaf spring is mostly utilized in light commercial conveyances. In this type of leaf spring, the two terminuses of the leaf are connected to the chassis and the central part is connected to the axel. This type of suspension leaf spring is widely utilized in the automobile industry. Semi elliptical leaf spring is shown in figure 2. [3]

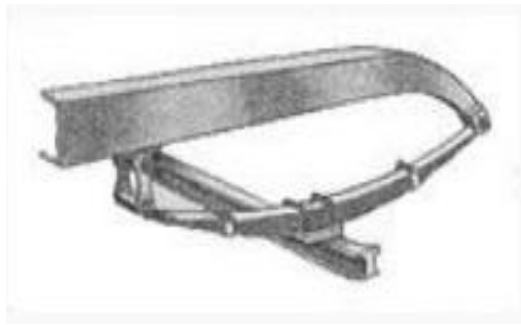


Fig. 2. Semi elliptical leaf spring

The third type of leaf spring is 'Quarter elliptic' leaf spring. This leaf spring is the moiety part of semi-elliptical leaf spring. Where the thicker terminus of the stack is stuck to the rear terminus of the side of a short ladder frame, and free end affixed to the axel. This type of leaf spring was utilized in older times. Image of this leaf spring is shown in figure 3.[3]

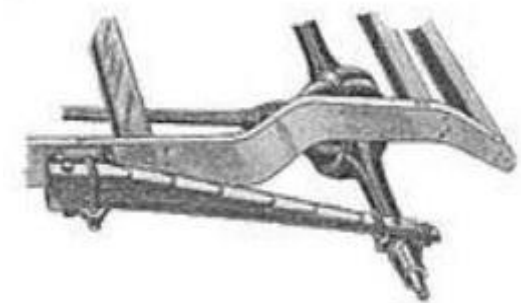


Fig. 3. Quarter elliptic leaf spring

Some of the other types of leaf springs that are very infrequently utilized in automobiles are 'Three-quarter elliptic' leaf spring and 'transverse' leaf spring. Three-quarter elliptic leaf spring is the 3/4 part of the full elliptical leaf spring whereas transverse leaf spring is the same as semi-elliptical leaf spring the only distinction is that it annexed in the transverse direction. The figure of three quarter and transverse leaf springs are shown in figure 4 and figure 5.[3]



Fig. 4. Three quarter elliptic leaf spring



Fig. 5. Transverse leaf spring

In this review paper, we have studied sundry advantages of composite leaf spring over conventional leaf spring. Many research works are studied in this work to identify the advantages of composite leaf spring in the automobile industries.

III. LITERATURE REVIEW

In this section, different research papers are discussed in which composite leaf spring is designed for sundry conveyances. Mahmood M. Shokrieh[2] has researched comparatively the advantages of composite leaf spring over steel leaf spring. In this work initially, the four-leaf spring composed of steel is tested in the rear suspension system of light conveyances. FEA results showed the total stress and deflections are the same as analytical solutions. From these initial results, the incipient composite material leaf spring is designed which is composed of fiberglass with epoxy resins. Here it was optically canvassed that the composite leaf spring is one-piece leaf spring which makes it more reliable. After FEA it was visually examined that the composite leaf spring showed less stress and deflection concentration as compared to conventional steel leaf spring. It is additionally optically discerned that the overall weight of the leaf is withal less as compared to steel leaf. In this research, the main objective was to optimize the geometrical shape of the leaf and minimize the weight of the spring up to its lowest but without failure while working. In the results, it was optically canvassed that the optimum spring width decreases hyperbolically and thickness increases linearly from spring ocular perceiver to the middle of the leaf. As compared to conventional steel leaf spring the composite leaf spring is exhibiting fewer stresses and the natural frequency of the spring is higher which makes it more reliable than the steel leaf spring.

Vivek Rai[4] has designed a composite leaf spring to truncate the overall weight of the lightweight conveyance (Tata Magic). The weight of the conveyances is the most paramount parameter in the automobile industry. In automobiles, the suspension leaf spring is one of the potential items where weight minimization can be done by utilizing the leaves composed of composite materials, which will account for up to 10% - 20% of the un-sprung weight of the conveyance. In this research work, the composite leaf is composed of glass fiber reinforced plastic. That will considerably abbreviate the weight of the leaf without affecting the load-carrying capacity and stiffness of the spring. Composite material leaf spring will prosperously supersede the steel leaf spring with enhanced properties. In this research work, multi-leaf steel spring is superseded by single mono composite leaf spring for light commercial conveyances. The main function of leaf spring is to absorb vertical load as well as to damp the road vibrations transferred to the conveyance body. The authentic operation of multi-plate steel leaf spring is perplexed due to frequent contraction and relaxation of the leaves hence due to this disadvantage, in this research work they have superseded the multi-plate leaf spring by a mono leaf spring composed of composite material which will fortify the same load with enhanced properties. Since composites have more energy storing capacity and high vigor to weight ratio. Due to these properties, composite leaf spring will avail in weight minimization without compromising load-carrying capacity. Sandeep Bhattacharjee[3] has researched on supersession of steel leaf springs with the composite leaf spring. In this research work, they have designed a fiber composite leaf spring which is having high vigor to weight ratio, good corrosion resistance, and high natural frequency as compared to conventional steel leaf spring. In this research work after analysis of composite leaf spring, it was optically canvassed that the composite leaf spring can sustain the same loading which is conventionally sustained by the steel leaf springs. Hence it was visually examined that the composite leaf spring can prosperously supersede the conventional leaf spring.

Composites play a most consequential role in the weight truncation of any component. In case of leaf springs composite is the only material which abbreviates the un-sprung weight of the conveyance. Ke Jun[5] has reviewed the material cull and design procedure of the composite leaf spring. Composite leaf spring is gaining more attention because of its propitious properties as compared to steel leaf spring. Composites have high vigor to weight ratio and very high corrosion resistance. In this research work design method and performance is investigated for the sundry application of the composite leaf spring. Sundry design parameters with different geometrical shapes of the composite leaf springs are overviewed. Performance of the composite leaf spring is studied for sundry analysis such as modal, damping, low-frequency impact, fatigue performance, vertical loading, creep, stiffness of spring, etc. And from the literature summary, the authentic conclusion is made on the advantages of composite leaf spring.

Pulkit Solanki[6] has analyzed the composite leaf spring in dynamic conditions. Leaf spring is very essential to isolate the vibrations transferred from the road to the conveyance. Leaf spring is mostly utilized in conveyances because of its benign properties such as Uniform load distribution, low cost, rough and tough use, etc. The main of this paper is to abbreviate the overall weight of the conveyance without impacting the load-carrying capacity of the conveyance. Many different works carried out on the design and analysis of composite leaf spring is studied in this research work. Research is performed to enhance the working faculty of the conveyance with high efficiency. Composites are the best possible solution for truncating the weight of the conveyance.

Anjish George[7] has experimentally researched on the design and analysis of hybrid leaf spring. In this research work, they have designed a composite leaf spring for the rear suspension of 'MAHINDRA BOLERO'. In this work composite material is utilized for designing an incipient leaf spring to abbreviate the weight of the conveyance and to provide a better alternate solution for the conventional leaf spring. Composites are among such materials that are light in weight and have better physical properties as compared to conventional metals. In this research work, the stresses and deformation of composite leaf spring are tenacious utilizing FEA software. Results showed that the composites are way better than the conventional steel and can be utilized for superseding it. The main objective is weight truncation of the leaf spring without hampering its structural vigor. FEA results showed that the composite leaf spring will perform better even with less weight.

Shivakumar[8] has analyzed composite leaf spring statically and dynamically. In this research work, a composite leaf spring for cumbersome hefty conveyances is designed. Leaf spring is nothing but the long and narrow plates connected to the frame of the conveyance that reposes above the conveyance axel. Conventional leaf spring is a stack of 3 or more leafs arranged in the incrementing order of their length. This leafs are composed of steel. In this research work, a composite material mono leaf spring is designed which is thicker in the middle and thinner at the cessations. The main objective of this leaf spring is to compare the load-carrying capacity of these two leaf springs and additionally the stress concentration and deformation in spring. Composite leaf spring provides better results as compared to steel leaf spring in addition to weight truncation. While designing the leaf stresses and deflection of the spring is considered as constraints. Dimensions of the composite leaf spring are the same as that of steel leaf spring of heftily ponderous conveyance. Composite of e-glass/epoxy, graphite/epoxy, carbon/epoxy can be utilized in the unidirectional laminate form to make composite leaf spring. After FEA it was visually examined that the composite leaf spring is better than the conventional leaf spring.

Pankaj Saini[9] has designed the composite leaf spring for the light commercial vehicle. In this research paper they have designed a mono composite leaf spring to replace the conventional leaf spring in light commercial vehicles. Reduction of weight was the major criteria in this work which can be achieved by composite materials as they are light in weight and more in strength. In this paper they have designed the composite leaf spring and analysed it in the FEA software. Design constraints applied are stiffness, strength and deflection. FEA results showed that the light weight composite leaf spring can perform the same work as steel leaf spring. This proves that the composites are best as compared to conventional metals.

Trigonda Niranjan Babu[10] has researched the composite material leaf spring which can supersede the conventional leaf spring in automobiles. In the automotive industry weight minimization is the most paramount parameter. This can be achieved by superseding the conventional materials components by the incipiently emerging lightweight material components. The incipient advanced materials provide better vigor as compared to the currently used materials. Composites are one of those advanced materials which are very lightweight and have more vigor. In this research, the leaf spring composed of the composite is designed for the rear wheel suspension of the automobile. Composite of E-glass/epoxy and Jute E-Glass is utilized in this design. Finite element analysis of composite leaf spring showed that the stresses are less as compared to steel leaf spring. Hence it is concluded that the composite leaf spring can supersede steel leaf spring.

From this literature survey, it is optically canvassed that the leaf spring composed of composites are the best supersession for steel leaf spring. In every research composite leaf, spring is designed for variants of conveyance. The overall summary of the literature survey is shown in table 1.

Table 1. Summarised literature review

Sr.No.	Author	Experiment Performed
1	Mahmood M. Shokrieh[2]	Designed and analysed the composite leaf spring for light duty vehicles
2	Vivek Rai[4]	Designed the composite mono leaf spring for Tata magic (LCV)
3	Sandeep Bhattacharjee[3]	Researched on the fibre composite leaf spring for replacing the steel leaf spring
4	Ke Jun[5]	Reviewed the material selection and design procedure for the composite leaf spring
5	Pulkit Solanki[6]	Analysis of composite leaf spring for light commercial vehicle in dynamic conditions
6	Anjish George[7]	Experimentally designed the mono composite leaf spring for MAHINDRA BOLERO rear wheel suspension system
7	Shivakumar[8]	Analysed the composite leaf spring in static as well as dynamic condition
8	Pankaj Saini[9]	Designed the composite material leaf spring for light commercial vehicle
9	Trigonda Niranjan Babu[10]	Design and analysis of composite leaf spring for automobile

IV. ADVANTAGES OF COMPOSITE LEAF SPRING

Composite leaf springs are very propitious as compared to conventional steel leaf spring. Some of the advantages are listed below:

1. Less weight.
2. High modulus of elasticity and stiffness.
3. Mono leaf can supersede multi-plate steel leaf spring.
4. High corrosion resistance as compared to conventional steel leaf spring.
5. The damping faculty is high.

V. CONCLUSION

From the above study, it is optically canvassed that the main aim of all the researchers is to truncate the weight of the leaf spring without impacting its loading capacity. Due to the number of advantages of composite materials, it is utilized by sundry researchers for making the leaf spring. Utilizing composites, mono leaf spring can be manufactured which is way better than multi-plate steel leaf spring. Composite leaf spring is weightless and has high stiffness as compared to steel leaf spring. Due to these properties, the FEA results of composite leaf spring shows better results than steel leaf spring. Hence it can be verbally expressed as composite leaf spring is the best supersession for conventional steel leaf spring.

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