International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 07 | July 2020 www.irjet.net p-ISSN: 2395-0072

DESIGN AND OPTIMIZATION OF MONO COMPOSITE LEAF SPRING

VAIBHAV CHAUDHARI[1], Dr. RAHUL B BARJIBHE[2]

[1]*M-TECH(Design Engineering) Student, Dept. of Mechanical Engineering, Shri Sant Gadgebaba College of Engineering & Technology, Bhusawal, Maharashtra, India,425203.*
[2]*Professor and* Dean, *Academics & Administration Dept. of Mechanical Engineering, Shri Sant Gadgebaba College of Engineering & Technology, Bhusawal, Maharashtra, India, 425203*

Abstract – *Leaf spring are the one of the commonly used suspension in the automobile vehicles. Leaf spring is the oldest suspension component in heavy load vehicle. Now-a-days in automobile and aerospace industries are working on the on weight reduction in the vehicle to get maximum efficiency throughout vehicle. We are studying on comparison of conventional leaf spring and mono composite leaf spring. The objective of present study was to replace material for leaf spring. In present study the material selected was glass fiber reinforced plastic (GFRP) and the epoxy resin can be used which was more economical this will reduce total cost of composite leaf spring. From analytical and FEA result the stresses in composite leaf spring are approximately 75% less as compared to conventional steel leaf spring under the same loading conditions. The deflection of composite leaf spring is approximately 10% more as compared to conventional steel leaf spring under same loading conditions. The weight of composite leaf spring is 65% is as compared to conventional steel leaf spring.*

Key Words: **Leaf spring, mono composite, finite element analysis**

1. INTRODUCTION

The steel leaf spring is main element of suspension system. It is working on the acceleration, breaking, Turing movement and load absorption. It is normally used to absorb load on the vehicle system. A spring is known to an elastic body whose function is to absorb the load and recover to the original shape when load is removed. The longest leaf known as main leaf or master leaf has its ends formed in the shape of an eye through which the bolts are passed to secure the spring to its supports. Usually the eyes, through which the spring is attached to the hanger or shackle, are provided with bushings or some antifriction material such as bronze or rubber. The other leaves of the spring are known as graduated leaves. Since the master leaf has to with stand vertical bending loads as well as loads due to sideways of the vehicle and twisting, therefore stresses caused by these loads, it is usual to provide full length leaves and the rest graduated leaves. Major disadvantages of steel leaf springs are: The weight of the leaf spring is more also

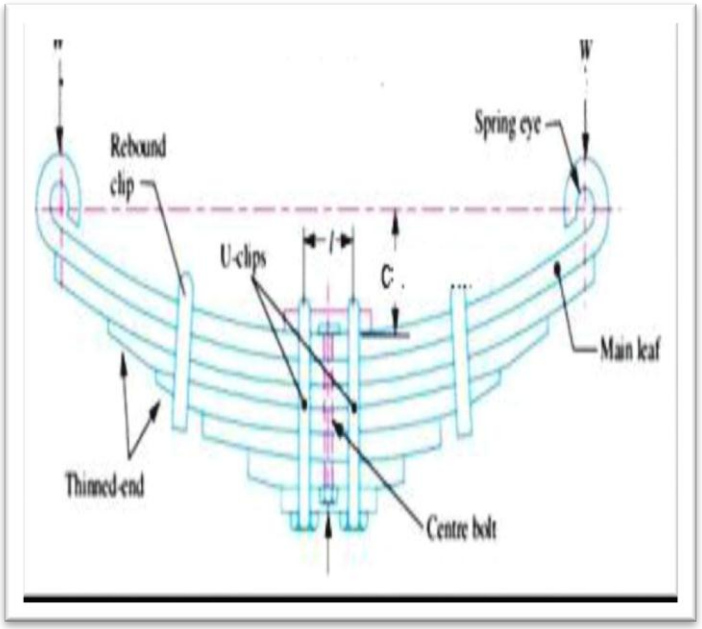


Fig- 1 Conventional Steel Leaf Spring

1.1 Aim

Now a day's automotive manufacturers companies are facing some problems and challenges. As market is growing so fast because of that people who investing their money they demanding more for their investment. Vehicle operator want his automobile should be on high performance comfort, refinement, safety as well as increased vehicle customization. These day government all over the world are strictly introducing to increase in fuel efficiency, reducing emissions, increasing recycling and greater safety for both pedestrians and occupants. For achieve these we can do proper design, optimization and better manufacturing process. We know that leaf is a one of heaviest component in suspension system to reduced weight. These will achieves

Vehicle with more fuel efficiency and improved riding qualities. Achieves the vehicle the introduction of composite materials was made it possible to reduce the weight of leaf spring without any reduction on load carrying capacity and stiffness. The main focus of automobile manufacturers in the present scenario to weight reduction has to done. The replacement of steel with optimally designed composite leaf spring can provides nearly 80% weight reduction.

1.2 Scope

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. These are some of the points with which we come to know the use of composite leaf spring instead of conventional steel is very effective in automobile industry. It helps in reducing weight of the vehicles, reducing fuel consumption and increasing efficiency of vehicles. Also stresses developed in composite leaf springs are less as compared to conventional steel leaf spring.

2. LITERATURE REVIEW

Abdul Rahim Abu Talia et al [1] in Developing a composite based elliptic spring for automotive applications gives information about In this study, optimize the material and geometry of the composite elliptical spring based on the spring rate, log life and shear stress parameters by using finite element models. The influence of the elasticity ratio on the performance of woven roving–wrapped composite elliptical springs was investigated both experimentally and numerically. The study demonstrated that composite elliptical springs can be used for light and heavy trucks with substantial weight reduction.

Mahmoud M. Shokrieh et al. [2] in Analysis and optimization of a composite leaf spring gives information about finite element analysis of leaf spring. By studying results its showing stresses and deflections analytical and experimental solutions. In paper by the steel leaf spring they design mono composite made by epoxy resin and is analyzed by ANSYS. Without getting failure to it obtain with minimum weight. Through the paper compare mono composite and steel leaf spring. Natural frequency is higher and the spring weight without eye units is nearly 80% lower.

Ravi Kumar V et al [3]. In Analysis of Natural Fiber Composite Leaf Spring gives information about Natural fibers are emerging as low cost, lightweight and apparently environmentally superior alternatives to glass fibers in composites. In the paper it shows comparison between Glass-Fiber-Reinforced - Composite (GFRC) leaf spring with a Natural-Fiber-Reinforced Composite/Jute-Fiber Reinforced Composite (NFRC/JFRC) leaf spring .Testing results leaf spring is experimented in Universal testing machine(UTM)and analysis is done by ANSYS software. Data shows composite material spring has stress much less than the steel spring .It reduced about nearly 60% to 70%.natural fiber composite is same strengths as e-glass epoxy with further weight reduction by 28%.

Malaga Anil Kumar [4] et al. in Design Optimization of Leaf Spring gives study about conventional leaf spring by mono composite leaf spring. On spring some load is carrying capacity and stiffness. By studying more about paper steel leaf is much less elastic strain energy storage capacity and high strength-to-weight ratio. In these further studying design of model is design in the CATIA and also Finite element analysis was done by the ANSYS .In conclusion the comparison of conventional steel leaf spring and mono composite leaf spring.

K. K. Jadhao et al. in [5] Experimental Investigation and Numerical Analysis of Composite leaf spring Author tell about design , manufacture and experimental testing and FEA analysis of composite spring which uses the material E-glass. . Since the composite leaf spring is able to withstand the static load, it is concluded that there is no objection from strength point of view also, in the process of replacing the conventional leaf spring by composite leaf spring. Since, the composite spring is designed for same. . The deflection or bending tests of both the spring for comparative study is taken on the universal testing machine.

V Pozhilarasu et al. [6]in Performance Analysis of Steel leaf spring with Composite leaf spring and Fabrication of Composite Leaf Spring gives information about a general study on the performance comparison of composite (Glass Fiber Reinforced plastic - GFRP) leaf spring and conventional leaf spring. Spring is design by the NX4 design software which unigraghics. Modeling and FEA analysis was done by the ANSYS 10.0. The comparison

between steel leaf spring and E-glass /epoxy were analyzed with same stress and displacement .By the testing Universal Testing machine results will compared by the FEA analysis. Under same condition of E-glass /epoxy is much higher than the conventional steel leaf spring.in conclusion shows about 3.5 times weight reduction. Mainly 71 % of material is saved by using the E-glass /epoxy over steel. It more effective and less cost will be study.

3. CONVETIONAL STEEL LEAF SRING

The leaf spring is mounted on the axle of the vehicle. The entire vehicle load rests on the leaf spring. Now-a-day material used for the steel leaf spring uses plain carbon steel. In plain carbon steel carbon percentage is about 0.90% to 10%. The steel leaf spring is manufactured by heat treated by forming process. By the processing steel we get high strength and greater load capacity. Steel leaf spring is on high range of deflection and good fatigue properties. In India for automobiles uses 50Cr1, 50Cr1V23, and 55Si2Mn90 all used in hardened and tempered state and rail road spring: C55 (Water hardened), C75 (Oil Hardened), 40Si2Mn90 (Water hardened) and 55Si2Mn90 (Oil Hardened).

3.1 Design parameter and material properties

Table -1: Specifications of Steel Leaf Spring [5]

Parameter	Value
Length of master leaf spring	1200mm
Free Camber	200mm
Thickness	6mm
Width	50mm
Ineffective length	200mm
Number of graduated leaves	6
Length of second Leaf spring	1150mm
Length of third spring	1000mm
Length of fourth spring	700mm
Length of fifth spring	580mm
Length of sixth spring	430mm
Length of seventh spring	300mm

The length of the leave springs are calculated by using the formulas given below

Length of $(n-1)^{th}$

$$\text{Leaf} = \frac{\text{Effective length}}{n-1} * (n-1) + \text{Ineffective Length}$$

4. MONO COMPOSITE LEAF SRING

A composite material is defined as a material composed of two or more constituents combined on a macroscopic scale by mechanical and chemical bonds. Typical composite materials are composed of inclusions suspended in a matrix.

Composite leaf spring is more strength than five time of steel leaf spring. As study had done be seen weight reduction. Mono composite leaf spring much less cost than conventional leaf spring. Selection material is an one of important aspect which selected by its manufacturing process. The composite material is most used in the civil structures, automobile industries, and in biomedical fields.

4.1 Selection of cross selection composite spring

Mono composite leaf spring cross section is one of aspect form manufacturing purpose following are some consideration [6]

1. varying thickness design, Varying width
2. Constant thickness, constant width design
3. Constant thickness, varying width design

For mass production of leaf spring, the constant thickness and constant width design process is good to use for mono composite leaf spring. Since the cross-section area is constant throughout the leaf spring, same quantity of reinforcement fiber and resin can be fed continuously during manufacturing.

4.2 Manufacturing of Mono composite leaf spring

After selection of material selection process manufacturing process plays an important role for getting specify and definite design. While considering manufacturing process it should be so simple and not so costly. It should be ease to get part and manufactured easily. Hand lay technique is one process which will suitable for the manufacturing.

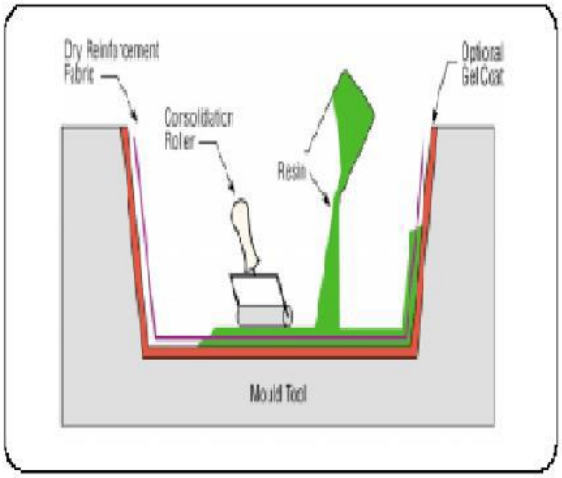


Fig- 2 Hand Lay-up Technique

The hand layup is one of the oldest and most commonly used methods for manufacture of the composite parts. Hand layup composite are a case of continuous fiber reinforced composite. Layers of unidirectional or woven composite are combined to result in a material exhibiting desirable properties in one or more directions.

4.3 Advantage of mono composite leaf spring

1. As compared to conventional material used in leaf spring it so light weight and high in the strength.
2. By using hand lay- up technique it is easily manufactured and good to use
3. As weight reduction occurred due to it will good for the fuel efficiency.
4. In Atmospheric pollution is so better in terms of corrosion.
5. After manufactured it low in the maintenance and no deformation will occurred due to load.
6. When load is imposed on the spring there is no wear and tear.

4.4 Limitation of composite leaf spring

1. The manufacture process and material section is initial cost will increased.
2. There are varies fiber is used in making of spring at certain time us will be occurred failure in spring.
3. As many automobile vehicles have some complicated design and manufacturing process so it not preferred for spring to implanted.

5. METHODOLOGY

After the design and manufacturing main step for getting result is do analysis of the spring. Which can be done through FEM (Finite element method).it is a computerized method to getting approximately solution on boundary condition which we can to apply on it .Boundary condition must be apply on the specific condition. Finite Element Analysis is a simulation technique which evaluates the behavior of components, equipment and structures for various loading conditions including applied forces, pressures and temperatures. After Design which generated CAD model which will imported to analysis software like ANSYS 11.0, Hyper mesh etc.

6. RESULTS AND DISCUSSION

Conventional steel leaf spring is designed [5].As Design is designed in CATIA design software and CAD file has exported to the ANSYS 11.0 and calculated Stress and Deflection. The analytical and FEA is compared. The design is analysis in different loading conditions. After Comparison of Results for Conventional and mono composite leaf spring as follows

1. Graphical representation of Load VS Deflection of Conventional steel leaf spring and Mono-composite leaf spring for Finite Element Analysis (FEA) result. The deflection of Mono-composite leaf spring is more as compared to conventional steel spring under the same loading condition.

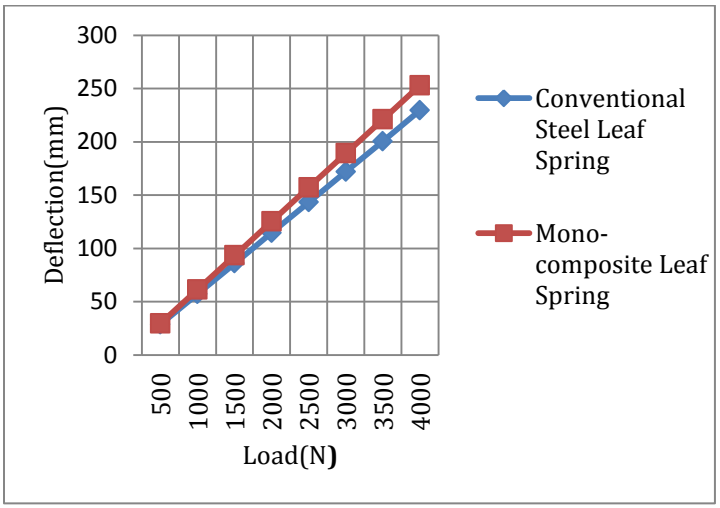
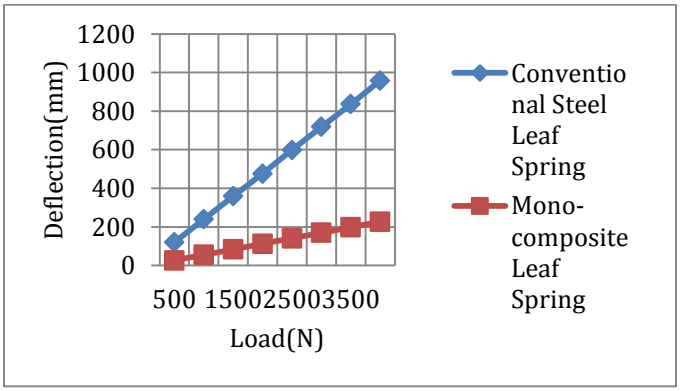


Chart -1: Graph of Load VS Deflection of Conventional steel leaf spring and Mono-composite leaf spring for Finite Element Analysis (FEA) result

2. Graphical representation of Load VS Stress of Conventional steel leaf spring and Mono-composite leaf spring for Finite Element Analysis (FEA) result. The stresses in mono-composite leaf spring are less as compared to conventional steel spring under the same loading condition



Graph -2: Graph of Load VS Stress of Conventional steel leaf spring and Mono-composite leaf spring for Finite Element Analysis (FEA) result.

7. CONCLUSION

As results shows above the graphs clearly tell us reduction of weight and also capable of carrying static load. We can suggest to replaced mono composite leaf spring over the steel leaf spring. Study is done on the comparison between the mono composite leaf spring an of spring with stress and deflection acting on spring. As we know steel is much cost. Mono composite has good factors of safety. Composite leaf spring non corrosives in nature, light weight a high in strain energy capacity. More experiments results gives fatigue test also. Due to laminate structure and reduced thickness of the mono composite leaf spring the overall weight would be less. As we reducing weight the fuel consumption would be reduced.Spirng having good damping capacity hence produced less vibration and noise.

8. FUTURE SCOPE

The study demonstrated that composites can be used for leaf springs for light weight vehicles and meet the requirements, together with substantial weight savings. The future potential for composites in these types of applications is discussed in terms of the fabrication developments which appear likely in the next decade. It is necessary to study the usage of composites in improving the performance and efficiency of these automobile components. For future work, we will trying for providing smooth curvature to Mono-composite leaf spring. Because of sudden changes in cross section stress concentration may done and it will increases the failure in leaf spring., if we providing smooth curvature, then chances of failure may reduce. Design of proper mono composite leaf spring will be god for the further study and usage. Also study can be done to replace a complete set of steel leaf spring with a mono-composite leaf spring for a vehicle and perform Fatigue tests.

ACKNOWLEDGEMENT

I take this opportunity to thanks Dr. R B Barjibhe for his valuable guidance and for providing all the necessary facilities, which were indispensable in completion of this work. First of all I am thankful to Prof A. V. Patil (H.O.D, Mechanical Engineering Department.) and also thankful to Dr. R B Barjibhe (Dean, Academics & Administration) to give us presentation facility. I am also thankful to all staff member of the mechanical Engineering Department. I would also like to thank the college for providing required journals, books and access to the internet for collecting information related to the project. Finally I am also thankful to my friends for their valuable comments and suggestions.

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