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STATIC AND FATIGUE ANALYSIS OF LEAF SPRING-AS A REVIEW

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ABSTRACT

In engineering there is need to reduce weight of vehicle for increasing or maintaining strength of component of the automobile. Where most important system in the vehicle is suspension system. Now in the light vehicles we are using coil spring instead of leaf spring due to failure of leaf spring. But leaf spring has some advantages as compared to coil spring. So we have to overcome this problem by replacing composite material into steel materials. Leaf spring contributes considerable amount of weight to the vehicle, leaf spring is designed and simulated following the design rules of the composite materials considering static loading. Leaf spring manufactured with varying cross section method. The varying cross section design of leaf springs is employed to take advantages of ease of design analysis and its manufacturing process. It is shown that the resulting design and simulation stresses are much below the strength properties of the material, satisfying the maximum stress failure. The designed composite leaf spring has also achieved its acceptable fatigue life. Prototype of leaf spring produced using hand lay-up method. Reducing weight and increasing strength of products are high research demands. Composite materials are getting to be up to the mark of satisfying these demands. We will determine the fatigue life of manufactured leaf spring and is compared with results of analytical and FEA results of existing leaf spring. As per above study we conclude on the basis of reference that the resulting design and simulation stresses are much below the strength properties which satisfying the maximum stress failure criterion.

Keywords: Ansys 14.0, FEA, Leaf Spring, Pro-E 4.0.

I.INTRODUCTION

Load acting on vehicle such as vehicle body load, external loads, To provide vertical compliance so that wheel can carry the uneven road, isolating the chassis from the roughness in the road, To maintain the wheels in proper steer and camber altitudes to the road surface, To react to the control forces produced by tires-longitudinal (acceleration, braking) and lateral forces (side loads on tilted vehicle), To resist roll of chassis so that proper balance of the vehicle is maintained. To keep the tires in contact with minimum load variation in the total system. Suspension system contributes some amount of load from the above loads for so we have to reduce this weight by replacing material. To conserve resources and save energy, weight reduction has been the main focus of automobile manufacturers in the present issue. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. Suspension leaf spring is one of the potential items for weight reduction in automobiles as it accounts for 10% - 20% of the unsprung weight. Because of this we achieves the vehicle with more fuel efficiency and improved riding qualities.

Replacing steel material by composite materials was made it possible to reduce the weight of leaf spring without reducing the load carrying capacity and stiffness. Since, the composite materials have high strength to weight ratio as compared with those of steel, mono steel leaf steel springs are being replaced by mono composite leaf springs. The cost of composite material is high comparatively weight saving. Current interest in reducing the weight of motor vehicles has brought numerous new applications for fiber reinforced polymers. Commonly, these applications involve a direct substitute for a part or an assembly.

II. LITERATURE REVIEW

Mr. Mallick P K, etal represents the first step in introducing fiber reinforced composite elliptic springs for automotive applications. Performance and failure modes of composite elliptic spring elements under static load conditions were also considered. Key design parameters, such as spring rate and failure load were measured as a function of spring (1).

Mr. Sardou, etal said that there are three ways to introduce composite on vehicle suspension. The first is to take away a metal leaf spring and put in place a composite leaf spring. Second is to design a composite axle doing anti roll as well as spring and guidance task. The last one is to design a metal suspension and to use composite spring only for its vehicle properties. First and second solutions design the composite to carry a complex job of wheel control and suspension spring. The task is rather complex for composite and end up with a relatively small benefit in weight and cost, on top of that suspension quality is relatively poor. However, in the field of vehicle suspension, the industry considers cost effective composite spring with minimum mass capable of resisting corrosion and possessing a high degree of durability. The automobile industry has shown increased interest in the replacement of steel leaf springs with composite leaf springs of glass fibre composites rather than others such as carbon fiber due to the cost factor(2).

Mr. Gulur Siddaramanna Shiva Shankar and et al have been studied that the development of a composite mono leaf spring having constant cross sectional area, here the stress level at any station in the leaf spring is considered constant and the parabolic type of the thickness of the spring, has proved to be very effective. The study demonstrated that composite material are used for leaf springs for reducing weight of vehicles and it meets the requirements, together with substantial weight savings. The 3-D modeling of both steel and composite leaf spring is done and analyzed using ANSYS 10.0. Where study of comparative analysis of leaf spring has been made between composite and steel leaf spring with respect to weight, cost and strength. Analytical results were compared with FEA and the results show best results. From the results, it is observed that the composite leaf spring is having less weight and more economical than the steel leaf spring with similar design specifications. As a results composite mono leaf spring reduces the weight by 85 % for E-Glass/Epoxy, 91 % for Graphite/Epoxy, and 90 % for Carbon/Epoxy over conventional leaf spring (3).

Mr. M. M. Patunkar and et al have been seen under the same static load conditions deflection and stresses of steel leaf spring and composite leaf spring difference is more. Deflection of Composite leaf spring is less as compared to steel leaf spring with the same loading condition. Conventional steel leaf spring was found to weigh 23 Kg. However E-Glass/Epoxy mono leaf spring weighs only 3.59 Kg. Which indicated reductions in weight by 84.40% same loading conditions. Conventional Leaf spring show failure at eye end only. At maximum load condition also Composite Leaf Spring shows the less deflection as compared to Steel Leaf Spring. Composite leaf spring can be used on smooth roads with very high performance expectations. On the rough road conditions due to lower chipping resistance failure from chipping of composite leaf spring is highly probable(4).

J P Hou and et al describes a new design of the double-leaf spring. Static tests show that the springs can carry safely the specified 150 kN maximum load. The composite double-leaf spring has similar static stiffness's to the steel spring that it replaces. Dedicated shaker rig has been used to collect valuable information on the dynamic response of the real system under various load conditions. Results have shown that the system at tare load needs more damping to ensure a smoother ride. Finite element predictions of stiffness, strain, and dynamic responses of the spring agree well with the experimental results. Which gives confidence in the use of finite element method for the design of composite springs and for performance predictions. The results from FEA also show that the bottom leaf can maintain the gross vehicle mass in the case where the top leaf fails by delimitation. Mode of failure is a safe one, as the eye end remains intact. Study of composite leaf spring in the early failed to yield the production facility because of inconsistent fatigue performance need for mass reduction. Researches in the area of automobile components have been receives considerable attention. Particularly the automobile manufacturers and parts makers have been attempting to reduce the weight of the vehicles in recent years. All these literature report that the cost of composite leaf spring is high as compare to steel leaf spring. Hence an attempt has been made to fabricate the composite leaf spring with the same cost as that of steel leaf spring. Where Material properties and design of composite structures are reported in many literatures. At the same time the literature available regarding experimental stress analysis is more. The experimental procedures are described in national and international standards. Recent emphasis on mass reduction and developments in materials and processing technology has led to proven production vehicle equipment (5).

Mr. Djomseu and et al said that there are three ways to introduce composite on vehicle suspension. First is to take away a metal leaf spring and put in place a composite leaf . Second is to design a composite axle doing anti roll as well as spring and guidance. The last one is to design a metal suspension and to use composite spring only for its vehicle properties. The First and second solutions design the composite to carry a complex job of wheel control and suspension spring. Task is rather complex for composite and end up with a relatively small benefit in weight and cost, on top of that suspension quality is relatively poor. However, in the field of vehicle suspension, the industry need a cost effective composite spring with minimum mass capable of resisting corrosion and possessing a high degree of durability. The automobile industry has shown increased interest in the replacement of steel springs with composite springs especially glass fiber composites rather than others such as carbon fiber due to the cost factor.

From the above literature it is clear that reduction in weight of leaf spring is the need of automobile industry with reducing cost and maintaining strength of leaf spring.

III. MODELLING AND FEA ANALYSIS

Both the springs are analyzed for static strength and deflection using finite element analysis. For steel leaf spring center bolt, u-clamp rebounded clip conditions are included in the boundary conditions. Non-liner 3D finite element analysis has been done to predict stress and deflection values. Fig. shows the location of boundary conditions & loading in the model. Through finite element modeling, analysis of steel and composite leaf spring will demonstrate the importance of contact modeling verses no contact modeling and reflects the results of deflections, stresses and strains.

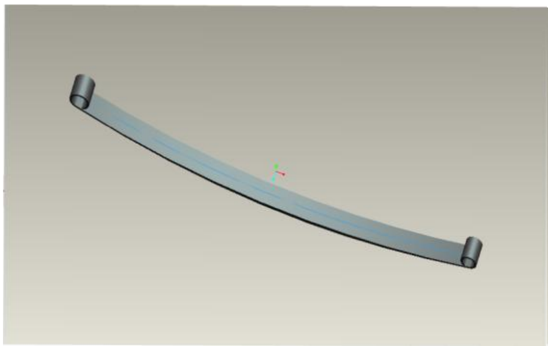

Fig. Model of Steel Leaf Spring in Pro-E 4.0

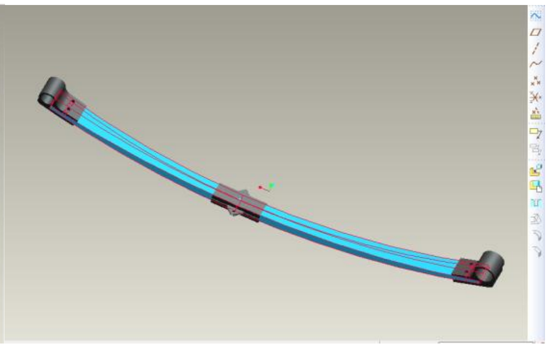

Fig. Model of Composite Spring in Pro-E 4.0

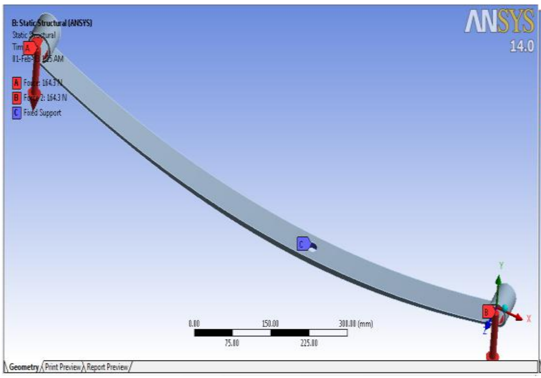

Fig. Boundary conditions and loading for Steel

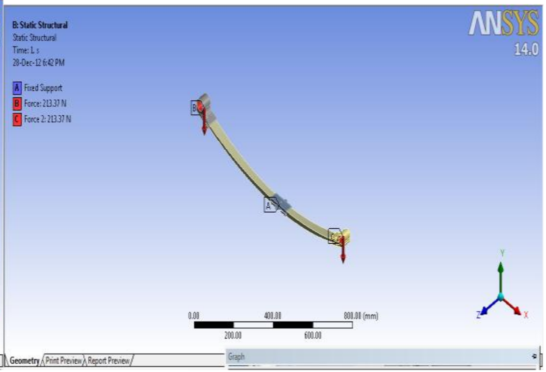

Fig. Boundary conditions and loading for Composite

IV. FINITE ELEMENT MODELLING

Figure shows the finite element model of the composite leaf spring where in it was meshed by taking edge length as 6mm as a result of which a total of 31068 elements and 36881 nodes were created.

No of Elements formed : 31068

No of Nodes created : 36881

Degrees of freedom:Translation in UX UY &UZ directions.

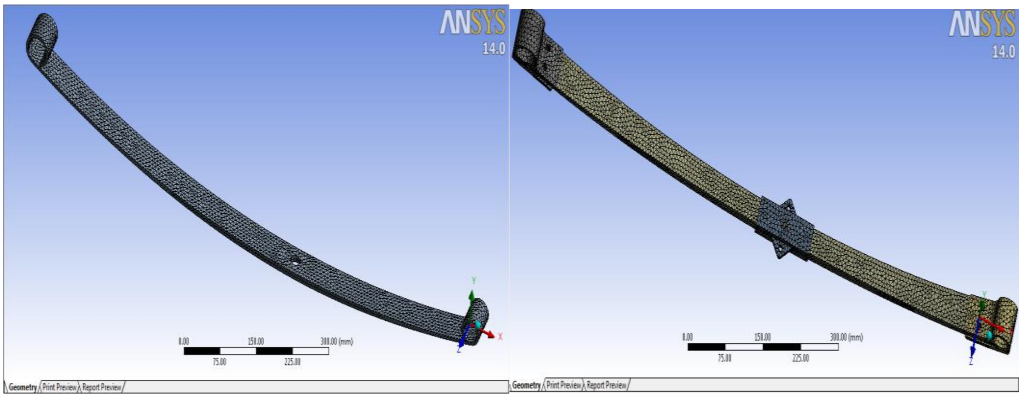

Fig. Meshed models of Steel and composite leaf spring with force and boundary conditions

V. STATIC ANALYSIS

A load of 1000kg is applied along the z direction and all degrees of freedom are constrained in one of the eye and x and y directions are constrained on the other eye. Figure 4.5 & 4.6 shows total deflection for two & five layered with maximum deflection being 101.5mm for two layer mode and 83.23mm for five layer modes. Figure 4.7 & 4.8 shows Von mises stress for two & five layered with maximum deflection being 795.4Mpa for two layer mode and 948Mpa for five layer mode.

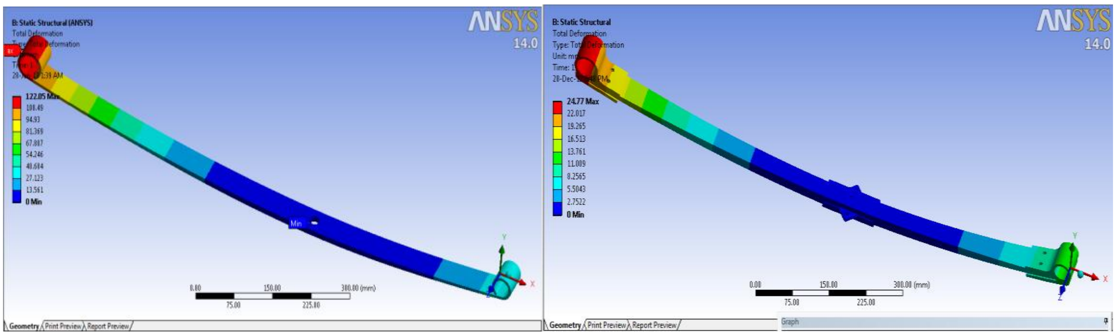

Fig. Deformation for steel and composite leaf spring

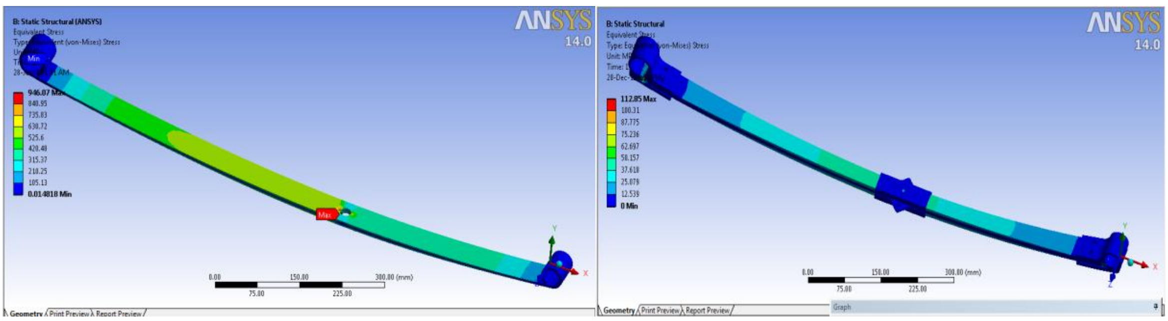

Fig Maximum stress near center for steel and composite leaf spring

VI.CONCLUSION

The leaf spring is design by considering as like a cantilever beam. The analysis purpose ANSYS software is selected as it gives good result and the analysis of composite leaf spring the SOLID46 element is selected and meshing is done with Hypermesh. The fabrication of constant width varying thickness leaf spring is fabricated with the help of hand lay-up method. In almost all the paper it is concluded that by using composite material weight reduction is obtain with many other advantages such as reduction in noise, increasing in comfort ride.

Lot of research has been done on fiber reinforced polymer composites but research on Epoxy resin based polymer composites is very less. From this, the present work has been undertaken, with an objective to explore the potential of Glass fiber polymer composites and to study the mechanical and wear characterization of different composites.

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