Design and Structural Analysis of Leaf Spring

Tarun kumar [1], G.v.r.s.rao [2],Anand Kumar pathak3
[1](Mechanical Engineering, BM college of technology/ RGPV, India)
[2](Mechanical Engineering, BM college of technology/ RGPV, India)
[3](Mechanical Engineering, NIEST/ Indore, India)

Abstract:
Mathematical and computer modeling have been playing an increasingly important role in the computer aided engineering (CAE) process of many products since last 60 years. The present work consists of a leaf spring involving two supporting leafs with the main Leaf. Main leaf and the centre leaf are having a identical cross section throughout the length of the blade. The load is applied axially downwards at the eye ends of the main leaf and a double magnitude load is applied at the bottom of the bolt. In this present model polycarbonate, jute/epoxy composite spring materials are taken for the analysis of modified leaf spring and to conclude a proportional study is carried out in the results. The nut is firmly fixed by giving a fully constrained boundary condition on it. Tetrahedron mesh element is used for the discretization of the spring model. For the whole work i.e., from the modelling to the result generation CATIA V5R12 software is used and the obtained results are finally compared with the numerically obtained result of stress and deflection to validate the simulation results.

Keywords - *CAE, Leaf Spring, CATIA, Load, Deformation*

INTRODUCTION

The leaf spring is one of the oldest forms of springing. It is usually used on rear-wheel-drive vehicles because its simplicity and can be mounted longitudinally. Leaf springs usually consist of one or more flat springs, made of tempered steel. A number of leaves of different length are used to form a multi-leaf spring. They are held together by a center bolt that passes through a hole in the center of each leaf. It is also used to locate the axle on the spring. The axle is then clamped to the spring by U-bolts that wrap around the axle housing, and through a spring plate underneath the spring.

1.1 FUNCTION OF LEAF SPRING

The leaf spring performs following major functions:
First use of leaf spring is load bearing and providing support the vehicle, keeping it above the frame and axle. Larger vehicles that must not only support their weight but also their heavier loads may have additional or heavy-duty leaf spring.The leaf springs help to control the vehicle so that the tires keep in contact with the road. When the vehicle goes over a bump, the springs help to keep it from bouncing uncontrollably.The leaf springs absorb all the bumps and dips in the road, thus providing a more comfortable ride for the vehicle's occupants. The leaf springs also help maintain the vehicle's alignment since their very rigidity keeps the vehicle's wheels tracking straight.

1.2 INTRODUCTION OF CAE ANALYSIS

To solve the research problem, the research methodology is a systematic way. How research is done scientifically, it can be understood with the help of research method. What steps taken by the researcher to solve the problem, that we will discuss in research methodology. Research methodologies are of following groups:

1. If the data which is available is not sufficient to solve the problem, in that condition the first method is use. Which is known as, concerned with the collection of data.
2. To establishing relationship between the data and the unknowns, the statistical techniques are used which are in second group.
3. To evaluate the accuracy of the result obtained some methods are use which is in third group.

Finite Element Method
In 1943 by Mr. R. Courant, this method (FEA) was first developed, he obtain approximate solutions of vibration systems with the help of minimization of variation calculus and Ritz method for numerical analysis.
In finite element analysis, the design is discretize or subdivided into a series of elements that are connected by nodes. Material properties and element properties are specified to represent the physical properties of the model. Boundary conditions and applied loads are then defined to represent the operating environment for which the design is to be subjected and its simulation tool that enables engineers to simulate the behaviour of an entire structure.

LITERATURE REVIEW

U. S. Ramakanth & K. Sowjany[1], give "Design and analysis of automotive multi-leaf spring using composite materials". According to this Leaf springs are one of the oldest suspension components they are still frequently used, especially in commercial vehicles. The automobile industries have shown interests in replacement of steel springs with composite leaf springs due to high strength to weight ratio. Author give static analysis and calculate stress and deflection with the help of ANSYS. Result is Fatigue analysis is conducted with four approaches namely Goodman's approach, Gerber's approach, mean stress approach and Soderberg's approach, by applying a load of 1000N, with a loading condition from history data – SAE Transmission. From the above said approaches it is seen that Soderberg's approach shows a maximum value of life 1.171*107 cycles which is represented in blue colour in the life data figure and the least value of life is shown in red colour. And from the Soderberg's approach we find that the red coloured region is greater it shows less life compared to other approaches, hence it is most preferred in the analysis so the designer can increase the safety of the leaf springs.

Dara Ashok , M.V. Mallikarjun and Venkata Ramesh Mamilla[2], give "Design and Structural Analysis of Composite Multi Leaf Spring". According to this Multi leaf spring carries lateral loads, brake torque, driving torque in addition to shock absorbing. It is well known that springs, are designed to absorb and store energy and then release it slowly. Ability to store and absorb more amount of strain energy ensures the comfortable suspension system. Author give FE model of the leaf spring, which is generated in Pro-E 4.0 and imported in ANSYS-11 for finite element analysis, which are most popular CAE tools. The FE analysis of the leaf spring has been performed by discretization of the model in infinite nodes and elements and refining them under defined boundary condition. The design constraints are stresses and deflections. A comparison of both i.e. theoretical analysis and FEA results have been done to conclude. Result is, the finite element analysis of multi leaf spring is performed using ANSYS-11 workbench.

DEVELOPING CAD MODEL

CAD model is first prepared in CREO 2.0 and is converted in .iges format to export it to ANSYS CFXCreo is developed by parametric technology corporation and this is one of the fastest growing solid modeling software. As a parametric featured based solid modeling tool, it not only unites the three dimensional model (3D) parametric features with 2D tools, but also addresses every design-through-manufacturing process. The solid modeling tool used here allows us to easily import the standard format files with an amazing compatibility to other software's

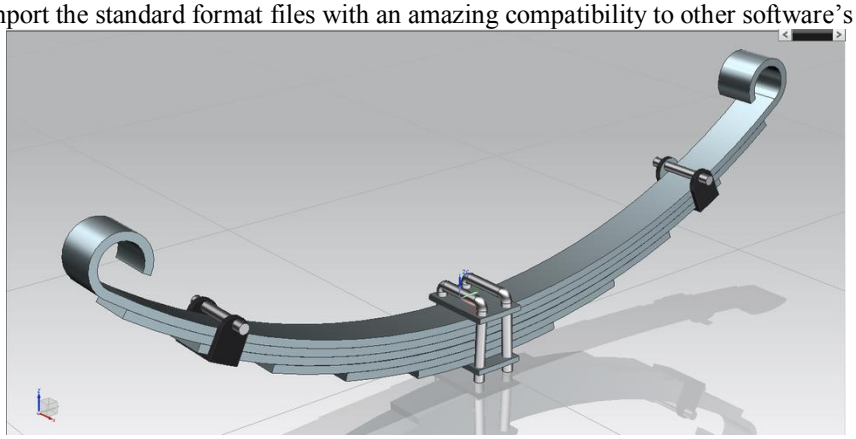
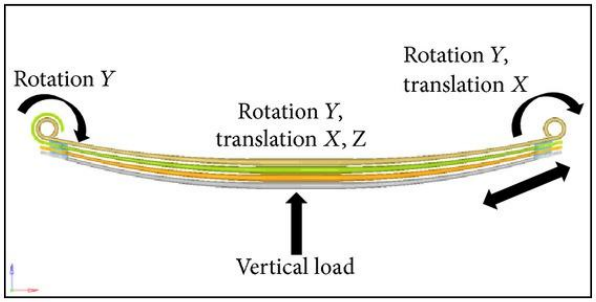


Fig 1.0 CAD model of leaf spring

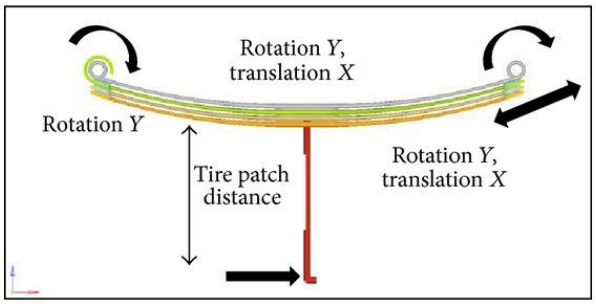
ANSYS SIMULATION

The CAD model is imported in ANSYS and enclosure is created. Using Boolean operation continuum is generatedThe appropriate size and shape of the computational domain, also referred to as control volume, and the best placement of the model in the domain, needs to be determined. A domain too large will make the simulation unnecessarily large and waste computational resources, however a domain too small will lower the accuracy of the results. The properties of the domain such as temperature, pressure and fluid properties need to be chosen.

4.1 Boundary Conditions:



(a)



(b)

Fig 2.0 Boundary conditions leaf spring

4.2 Discretization of the Domain:

Since ANSYS utilizes numerical solutions the domain needs to be discretezised or meshed as it is more commonly referred to. The mesh will have to be refined in areas with high gradients for example close to the surface around the leaf spring model. Initial Values need to be set for all the nodes in the domain.

RESULTS AND DISCUSSION

Analysis is performed for different materials at various load conditions are computed.

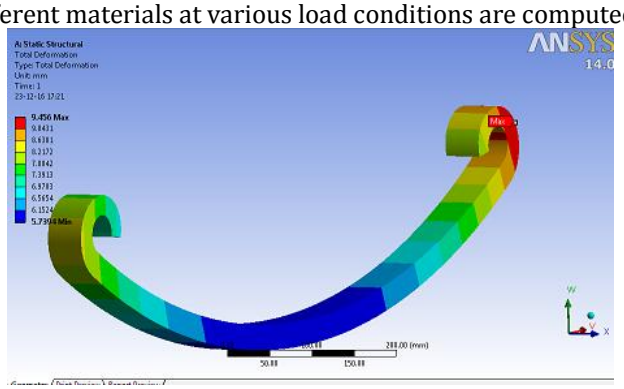


Fig 3.0 Deflection of steel material

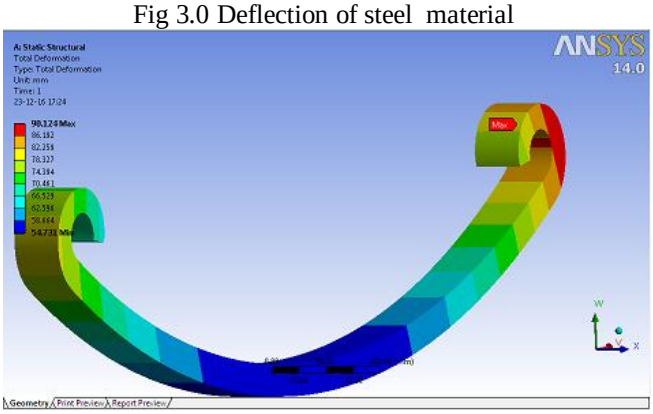


Fig4.0 Deflection of jute/ epoxy composite material

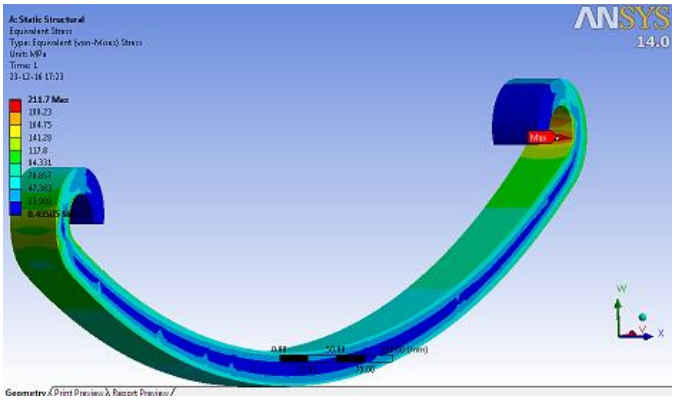


Fig 5.0 Vonmises stress of polycarbonate material

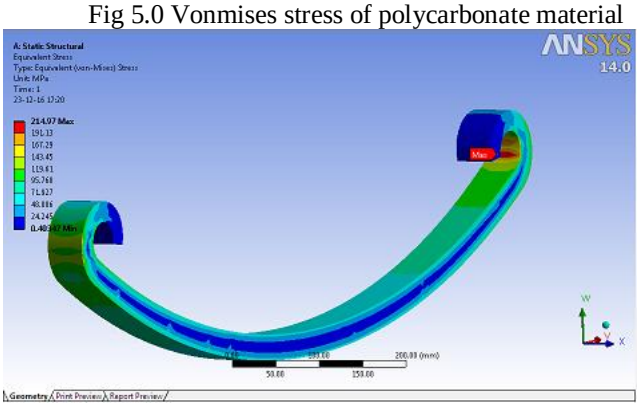


Fig 6.0 von mises stress of jute/ epoxy material

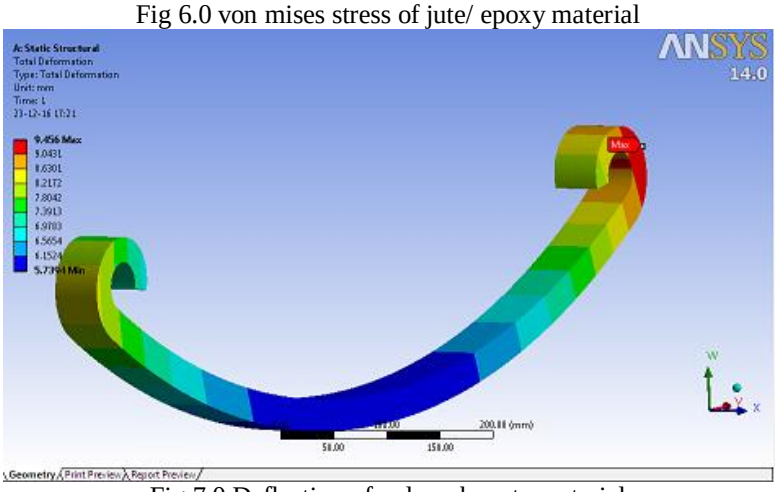


Fig 7.0 Deflection of polycarbonate material

Table 1.0 Result of leaf spring using Different material

	Maximum Displacement	Von Mises Stress
Steel	2.32 mm	$2.85^{\times}108$
Steel EN C35	2.27 mm	$2.78^{\times}108$
polycarbonate	9.456mm	211.7Mpa
jute/epoxy composite	98.14 mm	214.97Mpa

Generally leaf springs are not placed at a constant load condition. They are placed at fluctuating load or increasing load and they are made for such type of condition. So, for the proper designing and good material selection, it very necessary

to cheek the stress at different load condition. In the graph which is shown blow, the stress condition at different load has been shown and explanation is also given below

1. Steel is the exiting leaf spring material and in that when load is continually increase then von mises stress is also increase. But after a certain limit of load the stress is too high as compare to minimum load.
2. Polycarbonate is the material which is normally used to make a leaf spring and according to the analysis after a limit the stress is too high in it.
3. jute/epoxy compositeis the material which is normally used to make a leaf spring and according to the analysis it has been found that, the von mises stress is gradually increase when load is gradually increase. It's elastic property is also good as compare to other material.

CONCLUSION

It is concluded that the CAE tools provide a cost effective and less time consuming solution than the complex time consuming numerical solutions. According to the analysis it is concluded that leaf spring may be made by polycarbonate, jute/epoxy composite. Because it is more effective as compare to existing leaf spring material or other material (Iron, steel, steel EN C45).By which leaf springs are normally made. When load is increase then leaf spring displacement is also increase. Then after a certain limit iron, steel, steel EN C45 got fail. But, at that limit leaf spring which made by other materials is not fail. That means its elastic property is better than previous material and it's loading capacity is more as compare to other material. Component can be optimized if it is over designed and material can be saved or some of the parts can be strengthened by adding material at proper place.

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