IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

DESIGN AND DYNAMIC ANALYSIS OF SUSPENSION SYSTEM USING FEM METHOD

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Abstract: Suspension is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels. Suspension systems serve a dual purpose contributing to the vehicles handling and breaking for good active safety and driving pleasure and keeping occupants comfortable and reasonably well isolated from road noise and vibrations. The leaf spring suspension also protects vehicle itself and any cargo or luggage from damage and wear. In this project a leaf spring system is designed in Catia V5 tool and then finite element analysis is used to estimate the load that acts on the suspension and stresses and deflections in the suspension under the load is analyzed. These values vary as the boundary conditions of the tests are changed and are compared to a predetermined value from a reliable source. In analysis, the model is carried out in Ansys tool to determine the natural frequencies and corresponding node shapes. And load analysis is also performed to estimate the frequency response to see the stability of the suspension. A static analysis is also carried out to estimate the deflection and stresses due to working conditions, the design safety is ensured based on strength and rigidity.

Index Terms - Suspension, shock absorbers, springs, Catia V5, Ansys tool, and stresses

I. INTRODUCTION

Leaf spring is a simple form of spring commonly used for the suspension in wheeled vehicles. Originally called laminated or carriage spring, and sometimes referred to as a semi- elliptical spring or cart spring, it is one of the oldest forms of springing, appearing on carriages in England after 1750 and from there migrating to France and Germany. A leaf spring takes the form of a slender arc- shaped length of spring steel of rectangular cross-section. In the most common configuration, the centre of the arc provides location for the axle, while loops formed at either end provide for attaching to the vehicle chassis. For very heavy vehicles, a leaf spring can be made from several leaves stacked on top of each other in several layers, often with progressively shorter leaves. Leaf springs can serve locating and to some extent damping as well as springing functions. While the interleaf friction provides a damping action, it is not well controlled and results in stiction in the motion of the suspension. For this reason, some manufacturers have used mono-leaf springs. A leaf spring can either be attached directly to the frame at both ends or attached directly at one end, usually the front, with the other end attached through a shackle, a short swinging arm. The shackle takes up the tendency of the leaf spring to elongate when compressed and thus makes for softer springiness. Some springs terminated in a concave end, called a spoon end (seldom used now), to carry a swiveling member.

Figure 1 Leaf spring

The leaf spring has seen a modern development in cars. The new Volvo XC90 (from 2016-year model and forward) has a transverse leaf spring in high tech composite materials, a solution that is similar to the latest Chevrolet Corvette. This means a straight leaf spring that is tightly secured to the chassis and the ends of the spring bolted to the wheel suspension, to allow the spring to work independently on each wheel. This means the suspension is smaller, flatter and lighter than a traditional setup. Leaf springs were very common on automobiles, right up to the 1970s in Europe and Japan and late 1970s in America when the move to front-wheel drive, and more sophisticated suspension designs saw automobile manufacturers use coil springs instead. Today leaf springs are still used in heavy commercial vehicles such as vans and trucks, SUVs, and railway carriages. For heavy vehicles, they have the advantage of spreading the load more widely over the vehicle's chassis, whereas coil springs transfer it to a single point. Unlike coil springs, leaf springs also locate the rear axle, eliminating the need for trailing arms and a Pan hard rod, thereby saving cost and weight in a simple live axle rear suspension. A further advantage of a leaf spring over a helical spring is that the end of the leaf spring may be guided along a definite path. A more modern implementation is the parabolic leaf spring. This design is characterized by fewer leaves whose thickness varies from centre to ends following a parabolic curve. In this design, inter-leaf friction is unwanted, and therefore there is only contact between the springs at the ends and at the centre where the axle is connected. Spacers prevent contact at other points. Aside from a weight saving, the main advantage of parabolic springs is their greater flexibility, which translates into vehicle ride quality that approaches that of coil springs. There is a trade-off in the form of reduced load carrying capability, however. The characteristic of parabolic springs is better riding comfort and not as "stiff" as conventional "multi-leaf springs". It is widely used on buses for better comfort. A further development by the British GKN company and by Chevrolet with the Corvette among others is the move to composite plastic leaf springs. Nevertheless, due to missing inter-leaf friction and internal dampening effects, this type of spring requires more powerful dampers or shock absorbers.

II. Working Methodology

Leaf springs are a basic form of suspension made up of layers of steel of varying sizes sandwiched one upon the other. Most leaf spring setups are formed into an elliptical shape through the use of spring steel which has properties that allow it to flex as pressure is added at either end, but then returning to its original position through a damping process. The steel is generally cut into rectangular sections and the nonce held together by metal clips at either end or a large bolt through the centre of the leaves. It is then mounted to the axle of the vehicle using large U-bolts, securing the suspension in place. The elasticity of the spring steel allows for pliancy within the suspension for comfort and control of a car while moving, and a leaf spring setup has been proven as a viable option for cars for many decades, despite only really being found on HGVs and Military vehicles these days.

III. Design Methodology Of Leaf Spring Suspension

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault Systems. Written in the C++CATIA is the cornerstone of the Dassault Systems product lifecycle management software suite. CATIA competes in the high-end CAD/CAM/CAE market with Cero Elements/Pro and NX (Unigraphics). The 3D CAD system CATIA V5 was introduced in 1999 by Dassault Systems. Replacing CATIA V4, it represented a completely new design tool showing fundamental differences to its predecessor. The user interface, now featuring MS Windows layout, allows for the easy integration of common software packages such as MS Office, several graphic programs or SAPR3 products (depending on the IT environment). The concept of CATIA V5 is to digitally include the complete process of product development, comprising the first draft, the Design, the layout and at last the production and the assembly. The workbench Mechanical Design is to be addressed in the Context of this CAE training course Sets of workbenches can be composed according to the user's preferences. Therefore, Dassault Systems offers three different software installation versions. The platform P1 contains the basic features and is used for training courses or when reduced functionality is needed. For process orientated work the platform P2 is the appropriate one. It enables, apart from the basic design features, analysis tools and production related functions. P3 comprises specific advanced scopes such as the implementation of external software packages. CATIA can be applied to a wide variety of industries, from aerospace and defines, automotive, and industrial equipment, to high tech, shipbuilding, consumer goods, plant design, consumer packaged goods, life sciences, architecture and construction, process power and petroleum, and services. CATIA V4, CATIA V5, Pro/ENGINEER, NX (formerly Uni graphics), and Solid Works are the dominant systems.

3.1. Modeling of Leaf Springs in CATIA V5

This Leaf Spring is designed using CATIA V5 software. This software used in automobile, aerospace, consumer goods, heavy engineering etc. it is very powerful software for designing complicated 3d models, applications of CATIA Version 5 like part design, assembly design. The same CATIA V5 R20 3d model and 2d drawing model is shown below for reference. Dimensions are taken from. The design of 3d models done in CATIA V5 software, and then to do test we are using below mentioned software.

IV. Analysis Of Leaf Spring For Automobile Suspension System

4.1. Procedure for FE Analysis Using ANSYS:

The analysis of is done using ANSYS. For compete assembly is not required, is to carried out by applying moments at the rotation location along which axis we need to mention. Fixing location is bottom legs of rod assembly.

4.2. Preprocessor

In this stage the following steps were executed:
Import file in ANSYS window File Menu > Import> STEP > Click ok for the popped-up dialog box >Click

4.2.1. Finite Element Method:

In mathematics, finite element method (FEM) is a numerical technique for finding approximate solutions to boundary value problems. It uses variation methods (the Calculus of variations) to minimize an error function and produce a stable solution. Analogous to the idea that connecting many tiny straight lines can approximate a larger circle, FEM encompasses all the methods for connecting many simple element equations over many small sub-domains, named finite elements, to approximate a more complex equation over a larger domain. Finite element method (FEM) is a numerical method for solving a differential or integral equation. It has been applied to a number of physical problems, where the governing differential equations areavailable. The method essentially consists of assuming the piecewise continuous function for the solution and obtaining the parameters of the functions in a manner that reduces the error in the solution. In this article, a brief introduction to finite element method is provided. The method is illustrated with the help of the plane stress and plane strain formulation.

4.3. Analysis Procedure of Leaf Spring for Automobile Suspension System:

- Importing file in Ansys
- Imported file in Ansys from the system/ directory
- Replotting (Refresh) the component from the menu bar
- Giving Preferences to the solid component – Structural –ok
- Entering into preprocessor for selection of Element Type Entering into preprocessor for selection of Real Constraints
- Entering into preprocessor for selection of Material Model properties
- Entering into preprocessor for Volume controls values for mesh element size
- Entering into preprocessor for Meshing
- Entering into preprocessor for displacement of element.
- Entering into preprocessor for Force / Moment of element
- Image of Element where Loads are applied
- Window for solving the matrices problem, as done

V. Discussion On Analysis Result

5.1. Meshing

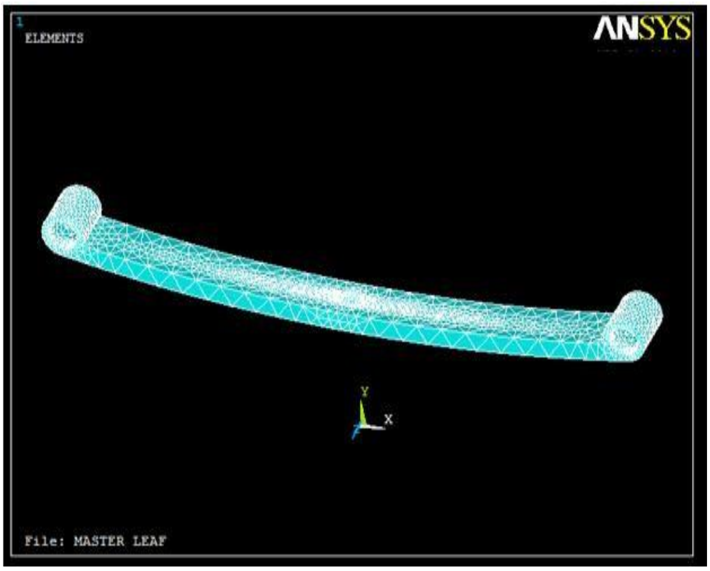


Figure 5.1.1 Master leaf

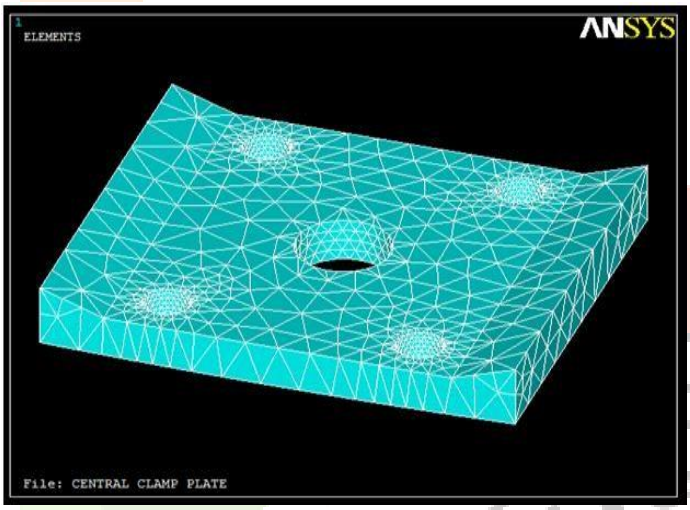


Fig 5.1.2 Central clamp plate

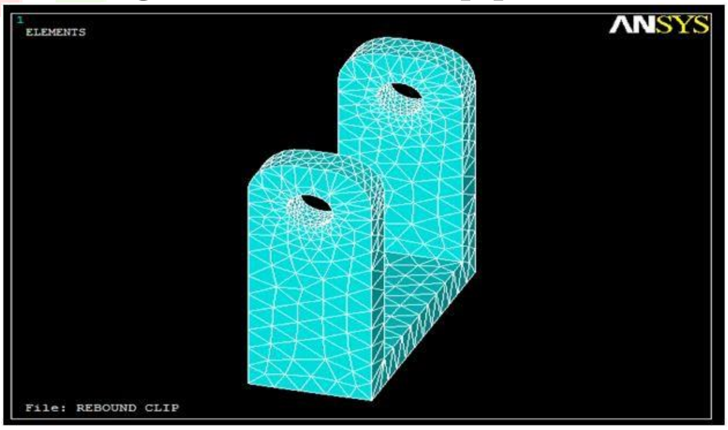


Figure 5.1.3 Foundation clamp

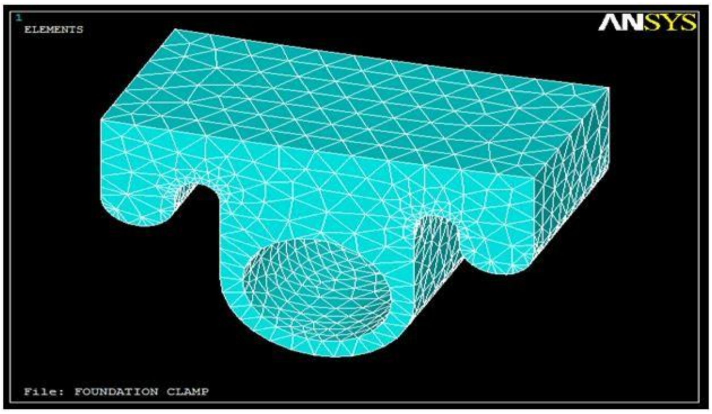


Figure 5.1.4 Rebound clip

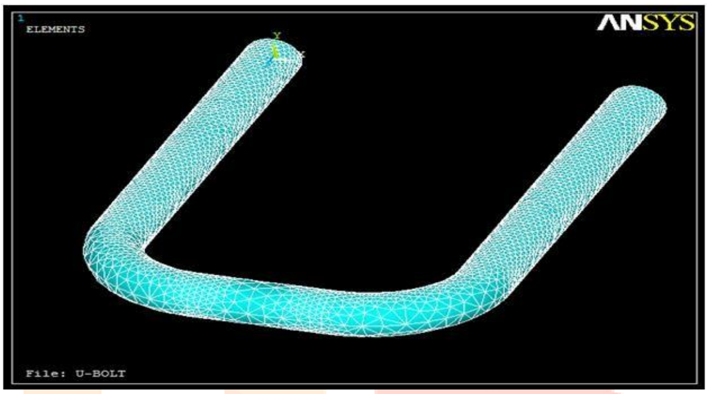
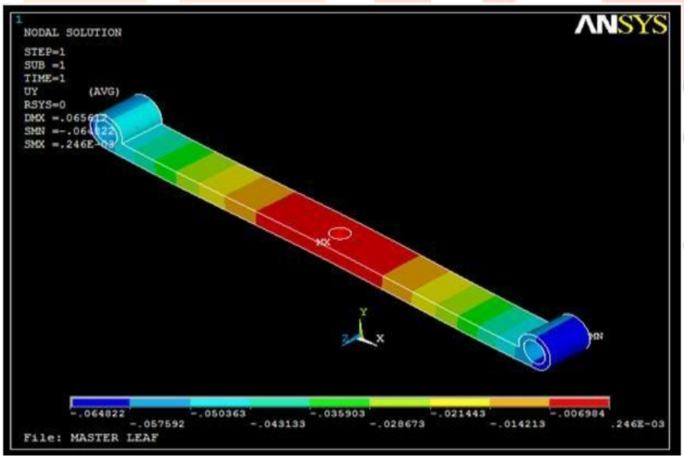


Figure 5.1.5 U-bolt



5.2 Displacement

Figure 5.2.1 Master leaf

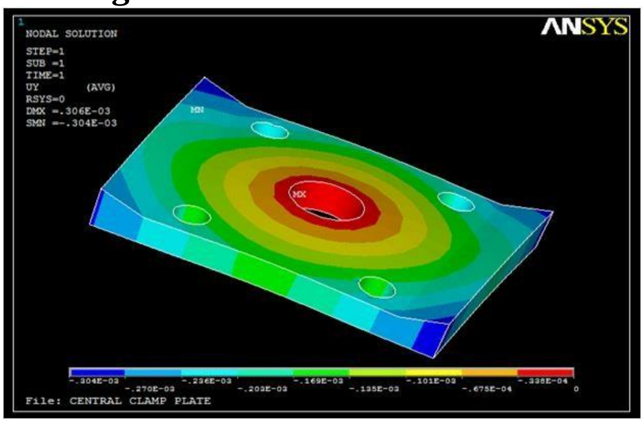


Figure 5.2.2 Central clamp plate

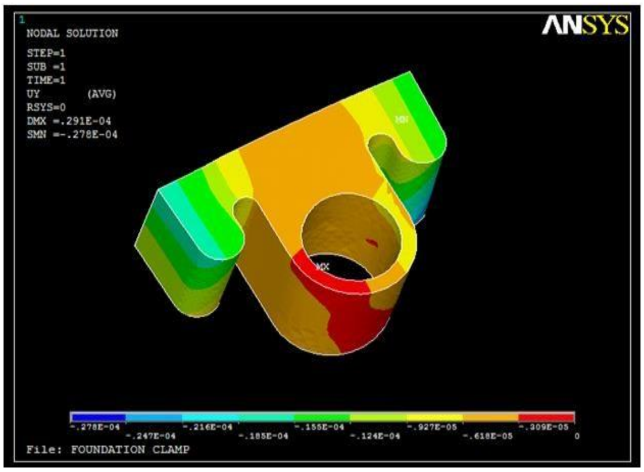


Figure 5.2.3 Foundation clamp

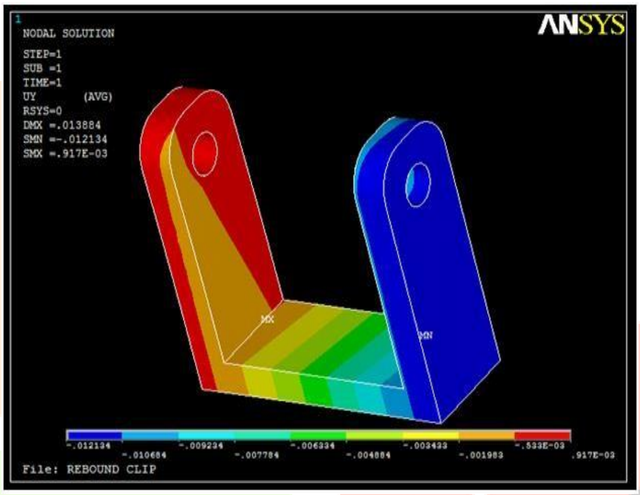


Figure 5.2.4 Rebound clip

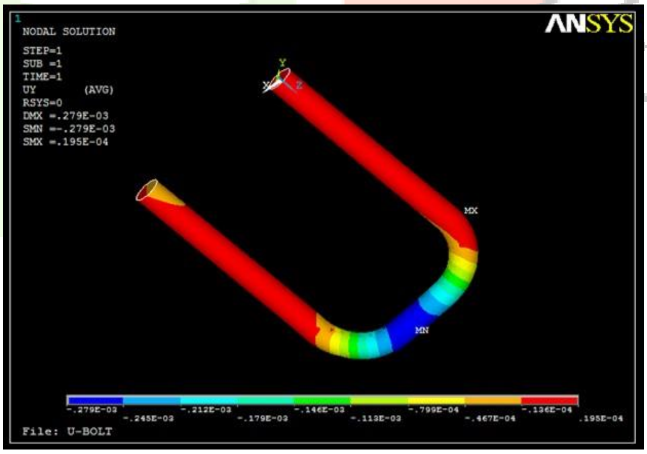


Figure 5.2.5 U-bolt

5.3 Stress

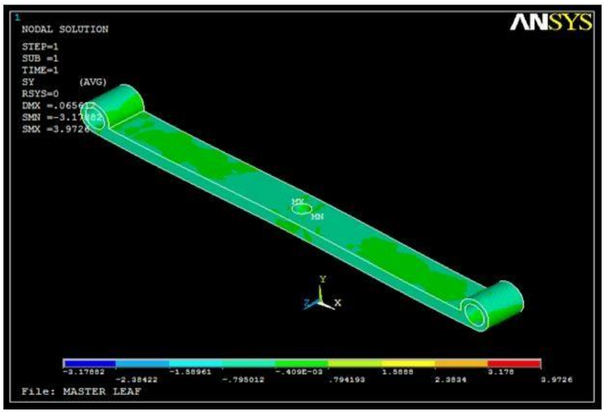


Figure 5.3.1 Master leaf

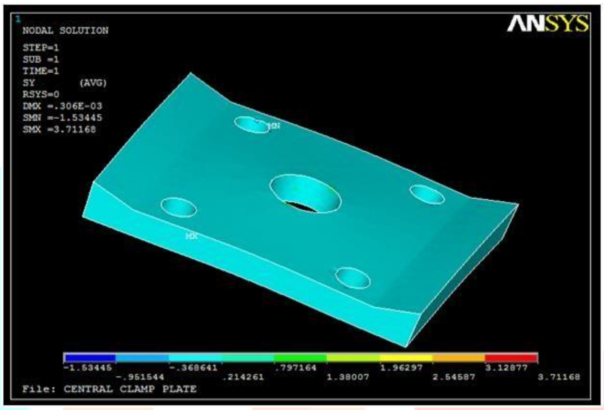


Figure 5.3.2 Central clamp plate

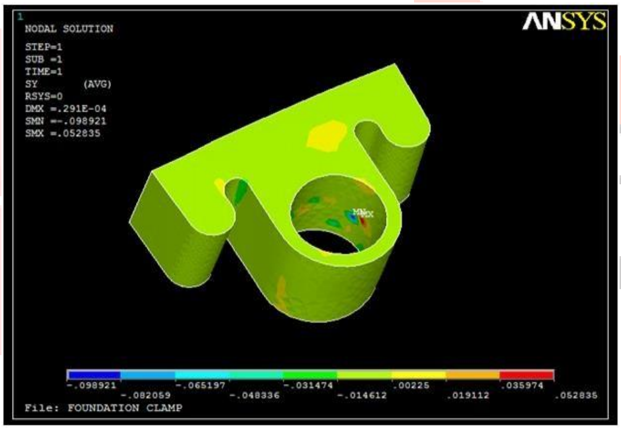


Figure 5.3.3 Foundation clamp

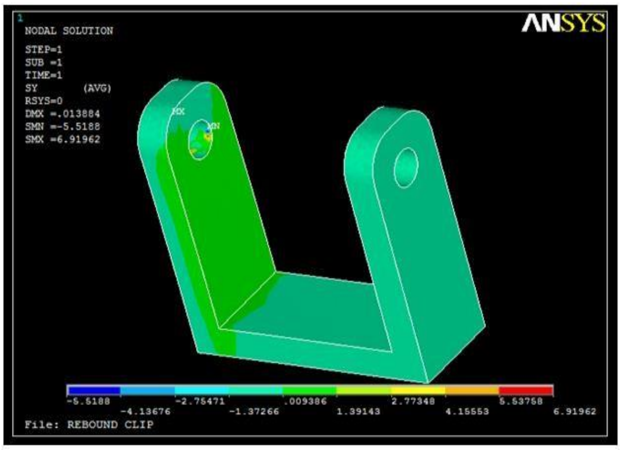


Figure 5.3.4 Rebound clip

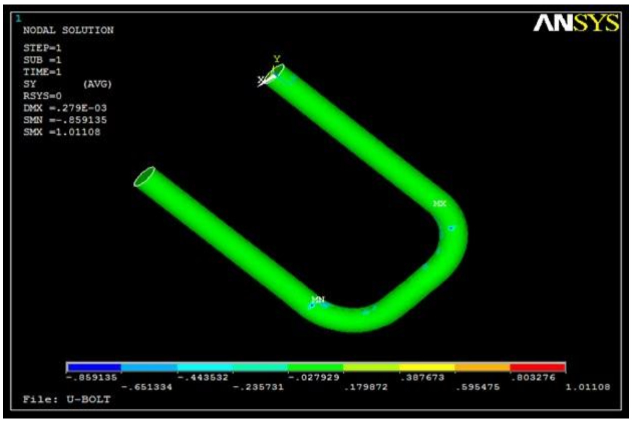


Figure 5.3.5 U-bolt

5.4 Strain

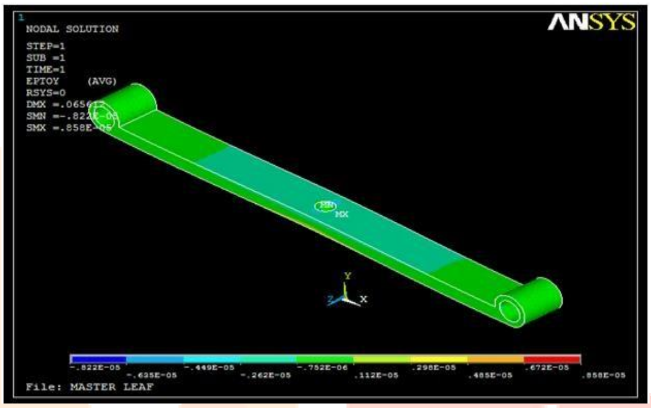


Figure 5.4.1 Master leaf

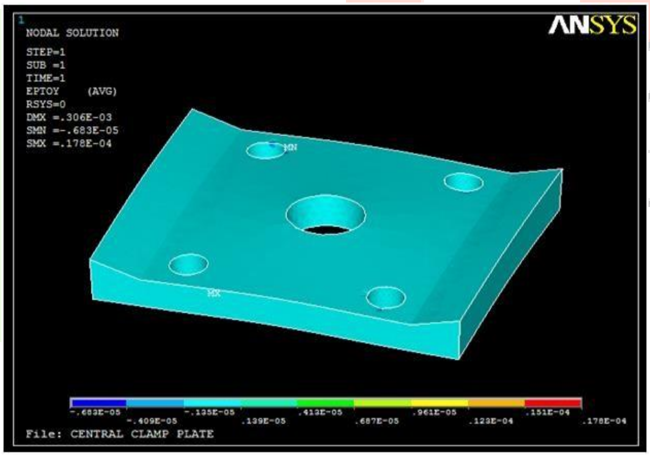


Figure 5.4.2 Central clamp plate

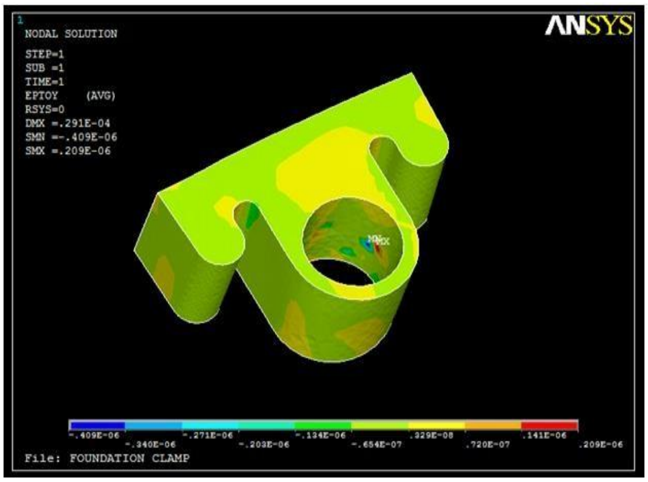


Figure 5.4.3 Foundation clamp

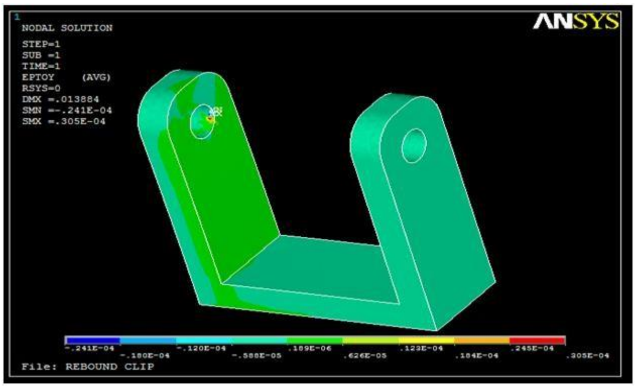


Figure 5.4.4 Rebound clip

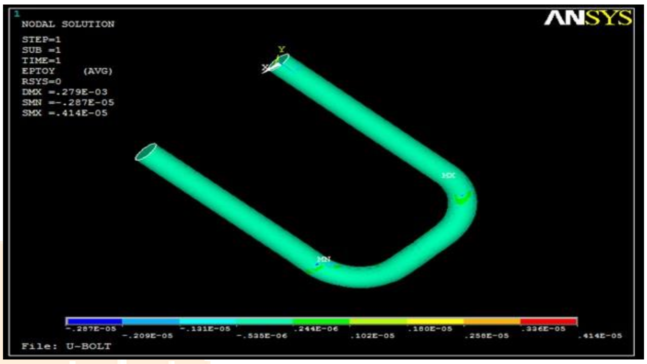


Figure 5.4.5 U-bolt

VI. Conclusion

It can be seen from the above result that, our objective to increase the results of a leaf spring in a curve has been successful. As shown above figures the displacement of the complete design assembly is meshed and solved using Ansys and displacement is 0.246E05mm which is very less. This is showing us that clearly each component in assembly is having minor displacement. Stress is at the fixing location (Minimum Stress which is acceptable). The value is 3.972MPa which is very less compared to yield value; this is below the yield point. The maximum strain is coming, this solution solving with the help of Ansys software so that the maximum strain is 0.858E-05MPa. So we can conclude our design parameters are approximately correct. The design of the leaf spring is worked flawlessly in analysis as well, all these facts point to the completion of our objective in high esteem.

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