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Design and Analysis of Leaf Spring Bracket Using ANSYS

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ABSTRACT

Automotive industry continues to strive for light weight vehicle in improving fuel efficiency and emission reduction performance and the reduction in vehicle weight is also aimed at achieving reduction in material cost. The leaf spring is a part of suspension system that is widely used in almost all commercial vehicles such as tempo, trucks etc. The leaf spring is attached to the frame using the leaf spring mounting bracket. As the bracket acts as a link between the chassis and suspension, it can be designed so that it had a low weight and can effectively transfer the stresses without failure. The project involves the design and analysis of leaf spring bracket to minimize the stresses at different load conditions. The objective of present work is to design and optimize the leaf spring bracket for the best material. The leaf spring bracket is designed in CATIA V5 and analysis was done in Ansys software. Materials selected are high carbon steel, alloy steel, structural steel is used against conventional leaf spring bracket. Evaluation of the materials has been done by comparing the materials one on the other, out of which alloy steel exhibited better results. Alloy steel is the best material which is capable of withstanding stresses that are developed in the leaf spring bracket rather than conventional steels which are used to manufacture leaf spring bracket.

KEYWORDS: Fuel Efficiency, Leaf spring, Bracket, Alloy Steel, Structural Steel

I. INTRODUCTION

Automotive industry is the largest growing &widely spread industry today. And the industry is continuing to strive for light weight vehicle in improving fuel efficiency and emission reduction performance.

Vehicle weight reduction is devoted to achieving fuel efficiency and reducing material costs. Concerns on decreasing the component cost in the automotive industry have recently increased because weight reduction of vehicles tends to improve fuel efficiency and reduce harmful emissions. The suspension system supports the weight of the vehicle and provides for a smoother ride for the driver and passengers. The job of a car suspension is to maximize the friction between the tires and the road surface, to provide steering stability with good handling and to ensure the comfort of the passengers. If roads were perfectly flat, with no irregularities, suspensions wouldn't be necessary but they are not therefore these imperfections interact with the wheels of a car and apply some forces on them. A bump in the road causes the wheel to move up and down perpendicular to the road surface. The magnitude depends on whether the wheel is striking a giant bump or a tiny speck. Either way, the car wheel experiences a vertical accelerations it passes over an imperfection. The suspension systems not only help in the proper functioning of the car's handling and braking, but also keep vehicle occupants comfortable and make your drive smooth and pleasant. It also protects the vehicle from wear and tear and also protects your vehicle from damage and play a critical role in maintaining safe driving conditions. A well functioning suspension system shields a vehicle and potential structural damage associated with prolonged exposure to bumps and pot holes but also keeps the wheels pressed firmly to the ground for traction .The suspension system isolates the body from road shocks and vibrations which would otherwise be transferred to the passengers and load. It also must keep the tires in contact with the road. When a tire hits an obstruction, there is a reaction force. The size of this reaction force depends on the un spring mass at each wheel assembly.

Figure 1: Leaf spring bracket

A bracket is integral component of suspension system that attaches between leaf spring and the vehicle frame. It allows for the leaf spring to work through length changes during suspension articution these are also supports vehicle weight since these are a primary component of the suspension system. As a leaf spring flexes up or down, it's length from main eye to shackle eye changes.

II. LITERATURE REVIEW

Radha Krishnan et.al.[1]:- Design and analysis of leaf spring shackle (ijiset 2015) They analyzed the leaf spring shackle and their analyzed results indicate that EN 45 material may be selected for the shackle material due to their lesser stress, deflection and deformation as compared to the existing material.

R.prakash [2]:- Design and analysis of leaf spring bracket in air suspension (ijirset 2013) they improved the existing model by addition of ribs in the side faces and they find that ribs are giving better stress strain distribution on the leaf spring bracket.

Mahesh Dasgaonkar et.al.[3]:- Design optimization and analysis of leaf spring using static load conditions (ijraset 2016) Analyzed Leaf spring model with S-Glass fiber and E-Glass fiber materials have lower mass compared to structural steel and titanium alloy. It is Observed that strain energy in E-Glass Fiber composite is higher as compared to other materials due to its energy storing capacity on virtue of its deflection.

YogeshSharma et.al.[4]:- Comparison of performance of multi leaf springs of automobile after changing its cross section (ijset 2015) Deflection of Modified leaf spring is less as compared to conventional leaf spring with the same loading condition. Modified Leaf spring shows failure At maximum load condition also Modified Leaf Spring shows the minimum stresses as compared to conventional Leaf Spring.Therefore Modified leaf spring can be used on smooth roads with high performance expectations.

Srinivasakurna et.al.[5]:- Investigation of stresses and deflection in multi stage leaf spring of heavy duty vehicle by fem (SAE 2015) Investigated about the stresses and deflection in leaf spring using fem and this study will help to understand more about the behavior of spring and give information for the manufacturer to improve the strength of the spring using CAE tool.

Sachin Patel [6]:- Modelling and analysis of two stage parabolic leaf spring under the static load condition by using FEA (IRJET 2016) Has analysed two stage parabolic leaf spring under the static load condition using FEA and observed that existing leaf spring stresses was exceeded the limit and validated new parabolic leaf spring to overcome this.

Satish Pavuluri [7]:- Experimental and finite element analysis of bogie suspension mounting brackets (SAE 2013) From Ashok Leyland, Ltd. Analysed bogie suspension brackets and This analysis helped to create a methodology to analyze suspension brackets.

Dr. SuwarnaTorgal et.al.[8]:- Simulation of parabolic leaf spring for heavy commercial vehicle using FEA (IJESRT 2015) Worked on multiple leaf spring having twelve leaves which comprises of five full length leaved and seven graduated leaves used in heavy commercial vehicle. Materials which are used in this analysis are steel, Ti6Al4V alloy, S-glass fiber composite. The results obtained showed that the strength to weight ratio is more than that of steel and Ti6Al4V alloy spring is two times less in weight when compared to steel leaf spring.

Vasudevrao S et.al.[9]:- Optimisation of brake actuator mounting bracket (Altair technology conference 2013) From Mahindra Engineering Services optimised existing mounting bracket using Altair Hyper Works Optistruct was their optimization tool. Objective was to minimize total static deflection of bracket. They achieved it within reduced time.

III. PROBLEM DEFINITION

The aim of the project is to design a leaf spring bracket using 3D modeling software CATIA. Traditionally, leaf spring brackets are made of plain carbon steel because a plain carbon steel leaf spring bracket are the cheap in cost, and has excellent ability to damp vibrations. However, the strength of the plain carbon steel cannot be increased beyond 700 Mpa and it has poor corrosion resistance. The implementation of alloy steel materials by replacing the exsisting conventional steel material leaf spring bracket of a suspension system to reduce product weight, improving the safety, comfort and durability

Usage of different alloys in design and development of leaf spring bracket can result in significant benefits to manufactures and consumers. Analysis is performed using commercial software ANSYS 15.0

IV. COMPUTER AIDED DRAWING AND ANALYSIS USING ANSYS

STEPS FOR CREATING LEAF SPRING BRACKET:

1) A 3d cad model is prepared In CATIA V5 part modeling. Leaf spring is attached to two brackets, one at front end and other at rear end.
2) After opening CATIA V5 Go to mechanical design then click on part design

Sketching operation

1) Select sketchers option and select the required plane surface.
2) After selecting plane, draw a line by using line command by using sketching tool bar.
3) Then, draw the outline of model and constrain the model with appropriate dimensions.
4) After that look for any open geometry has been drawn on the modeling.

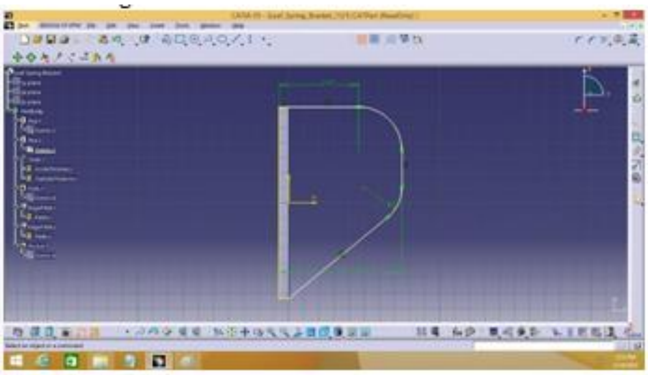

Figure 2: Sketching of the leaf spring bracket

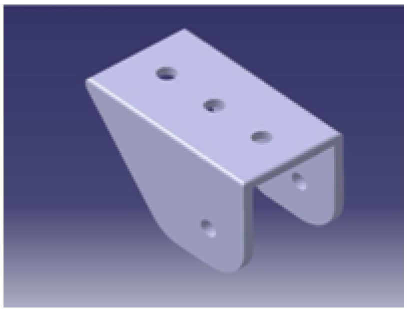

Figure 3: Leaf spring bracket in CATIA

Material selection:

High carbon steel: The alloys in this particular category constitute the strongest and hardest within the three groups, but they are also the least ductile.

Alloy steel (AISI 4140): Alloy steels are designated by AISI four-digit numbers and comprise different kinds of steels, each with a composition which exceeds the limitations of B, C, Mn, Mo, Ni, Si, Cr, and Va set for carbon steels AISI 4140 alloy steel is a chromium-, molybdenum-, and manganese-containing low alloy steel. It has high fatigue strength, abrasion and impact resistance, toughness, and torsional strength.

Structural steel: Structural steel is a category of steel used for making construction materials in a variety of shapes. Many structural steel shapes take the form of an elongated beam having a profile of a specific cross section Structural steel shape, sizes, chemical composition mechanical properties such as strengths, storage practices, etc., are regulated by standards in most industrialized countries.

Table 1: Properties of materials

Material	Density g/cm3	Tensile strength Mpa	Poisons Ratio µ
High carbon steel	7.85	635	0.28

Alloy steel	7.85	655	0.30
Structural steel	7.75	460	0.3

There are a number of steps in the solution procedure using finite element methods. All finite element packages require going through these steps in one form or another. First the geometry of the structure to be analyzed is defined. This can be done either by entering the geometric information in the finite element package through the keyboard or mouse, or by importing the model from a solid modeler like CATIA V5R20.

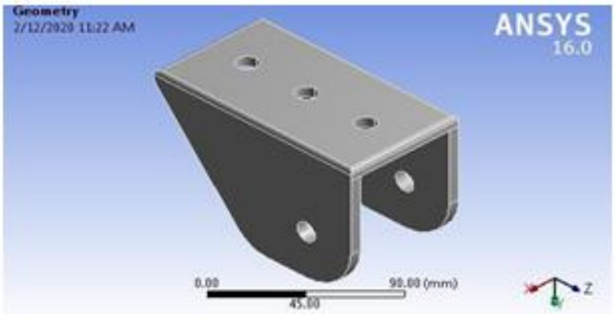

Figure 4: Leaf spring bracket in ANSYS

Then, the structure is broken (or meshed) into small elements. This involves defining the types of elements into which the structure will be broken, as well as specifying how the structure will be subdivided into elements (how it will be meshed). This subdivision into elements can either be input by the user or, with some finite element programs (or add-ons) can be chosen automatically by the computer based on the geometry of the structure(this is called auto meshing).

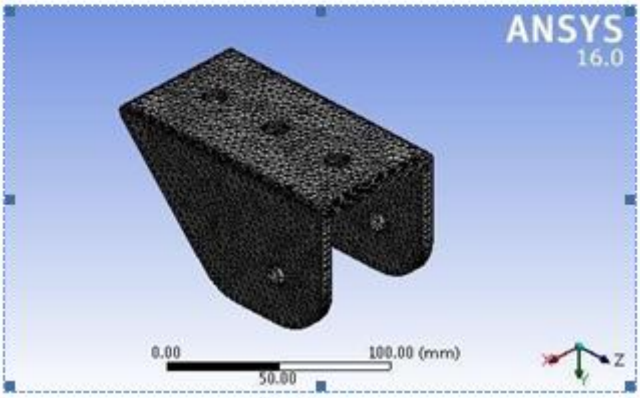

Figure 5: Meshed Body of Leaf Spring bracket

In this surface of mounting hole is fixed and the translation of upper surface made zero in the direction perpendicular to its surface (i.e. Z direction) and made free in other two directions.

Load of 4500 N is given at the two holes in which bolt of the leaf spring eye is supported as shown in figure below.

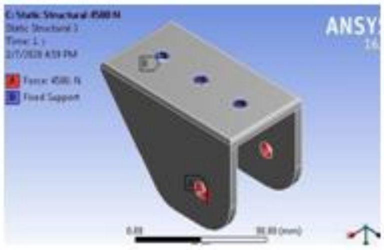

Figure 6: Boundary conditions of leaf spring bracket

V. Results and Discussions

High carbon steel:

The Bracket load at 3500N

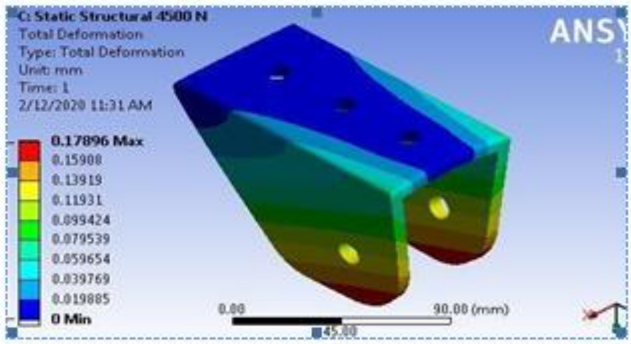

Figure 7: Total deformation of high carbon steel at 3500N

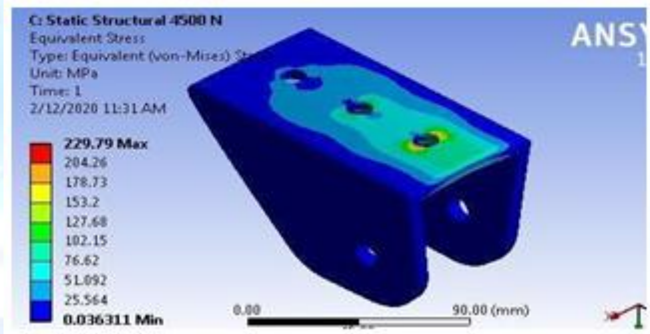

Figure 8: Equivalent stress of high carbon steel at 3500N

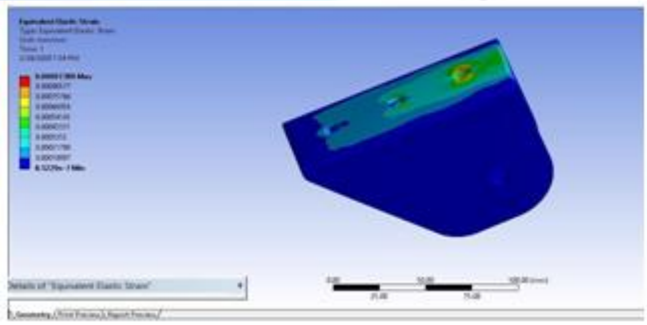

Figure 9: Equivalent elastic strain of high carbon steel at 3500N

The bracket load at 2500N

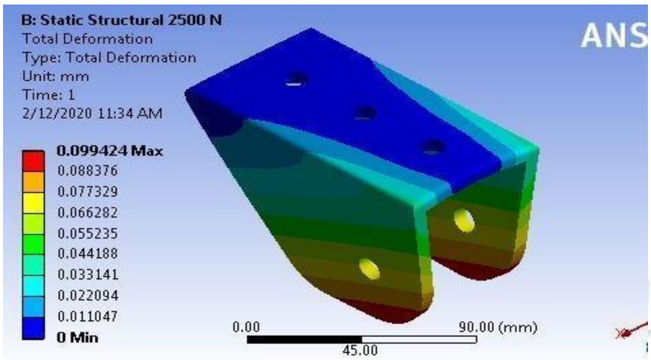

Figure 10: Total deformation of high carbon steel at 2500N

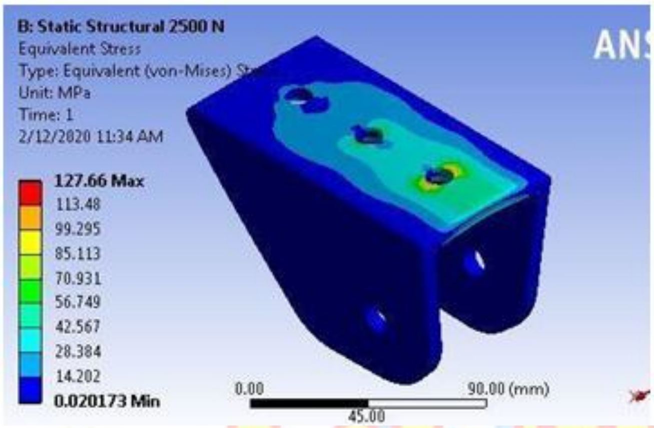

Figure 11: Equivalent stress of high carbon steel at 2500N

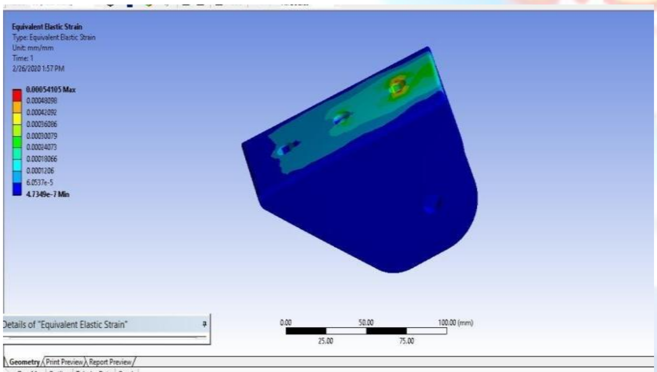

Figure 12: Equivalent elastic strain of high carbon steel at 2500N

Material 2: Alloy steel

The bracket load at 4500N

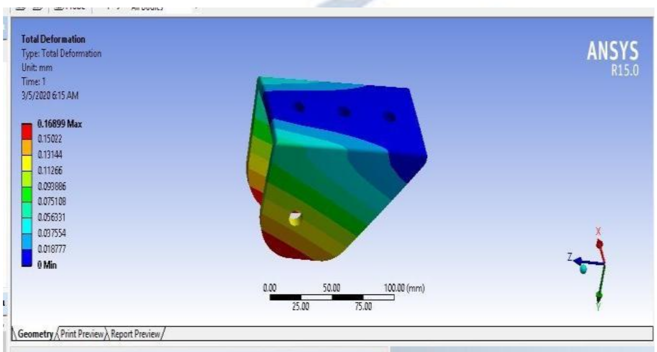

Figure 13: Total deformation of alloy steel at 4500N

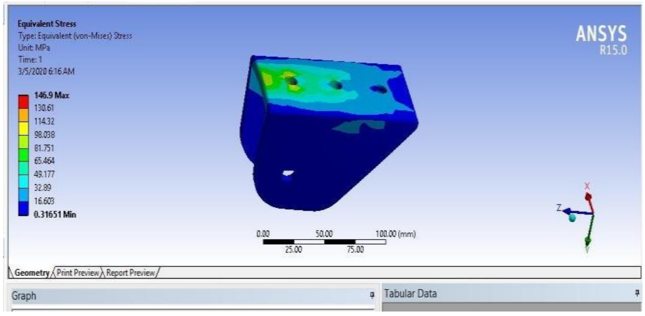

Figure 14: Equivalent stress of alloy steel at 4500N

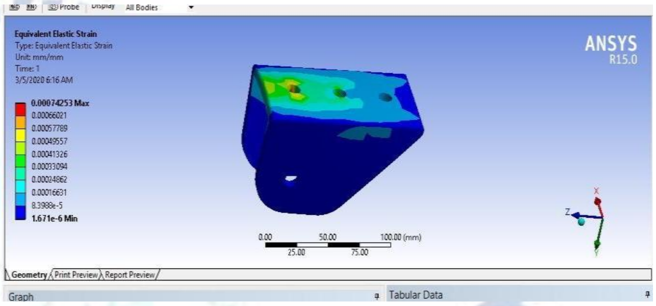

Figure 14: Equivalent elastic strain of alloy steel at 4500N

The bracket load at 3500N

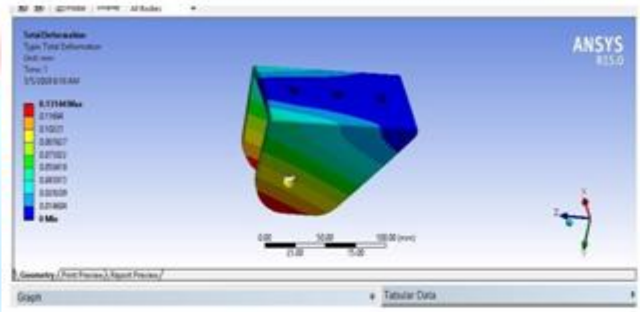

Figure 15: Total deformation of alloy steel at 3500N

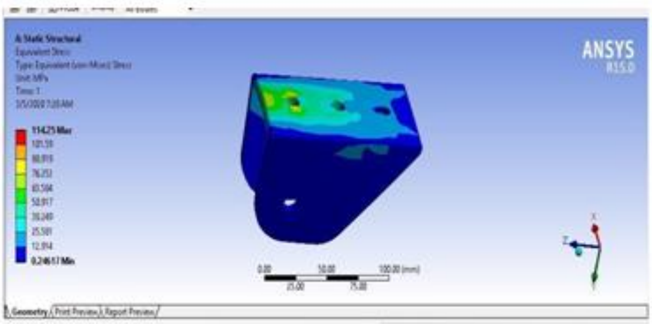

Figure 16: Equivalent stress of alloy steel at 3500N

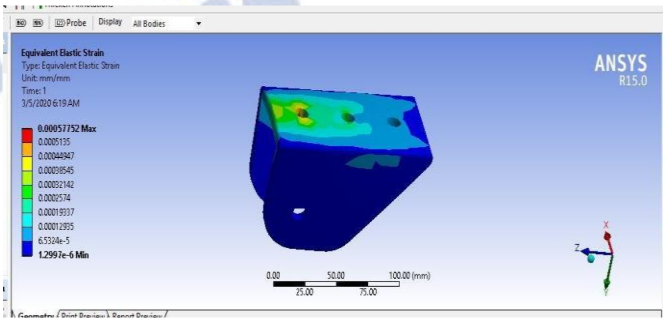

Figure 17: Equivalent elastic strain of alloy steel at 3500N

The bracket load at 2500N

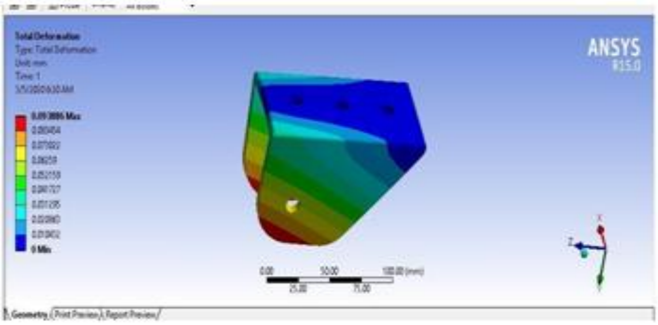

Figure 18: Total deformation of alloy steel at 2500N

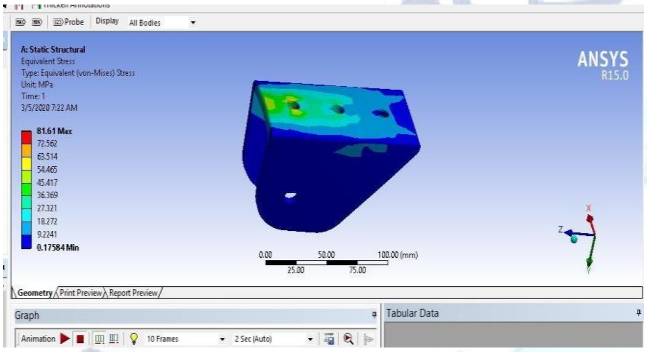

Figure 18: Equivalent stress of alloy steel at 2500N

Material 3: Structural steel

The bracket load at 4500N

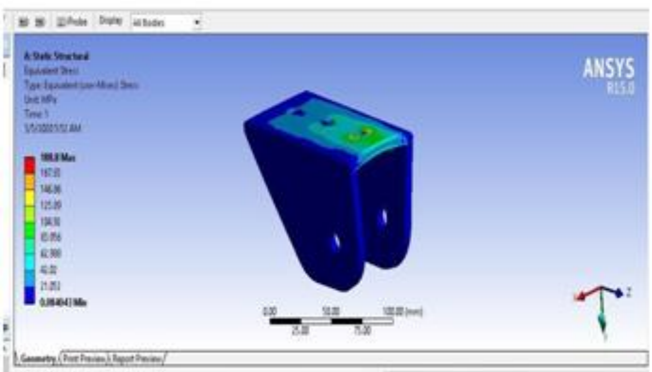

Figure 20: Equivalent stress of structural steel at 4500N

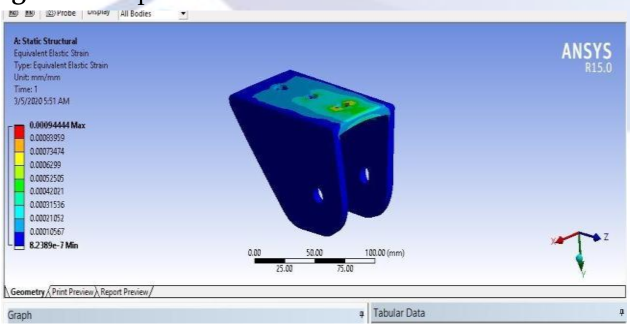

Figure 21: Equivalent elastic strain of structural steel at 4500N

The bracket load at 3500N

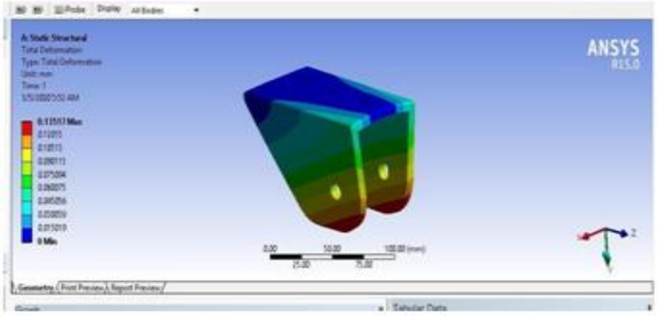

Figure 22: Total deformation of structural steel at 3500N

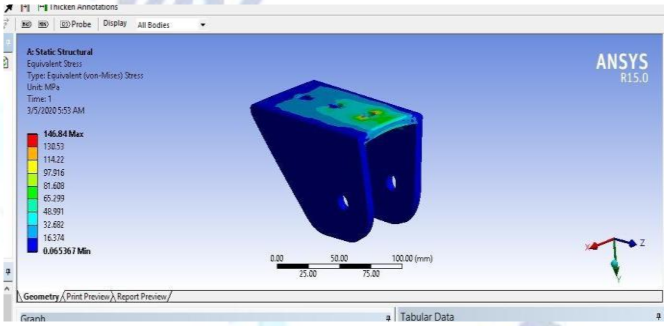

Figure 23: Equivalent stress of structural steel at 3500N

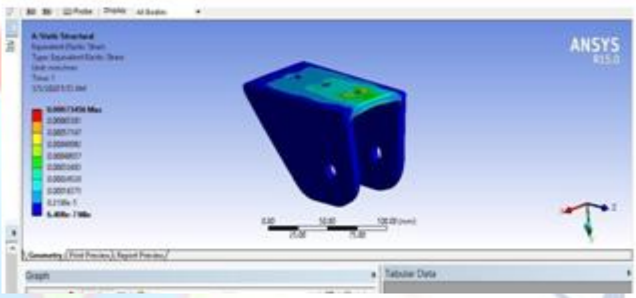

Figure 24: Equivalent elastic strain of structural steel at 3500N

The bracket load at 2500N

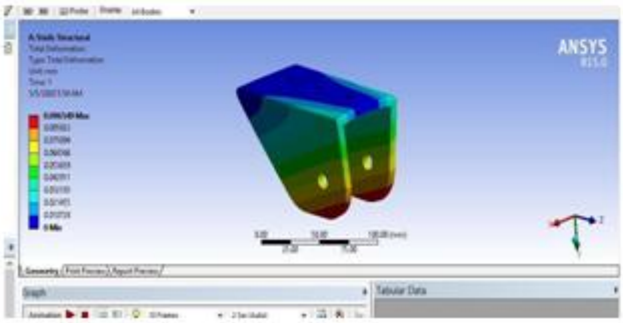

Figure 25: Total deformation of structural steel at 2500N

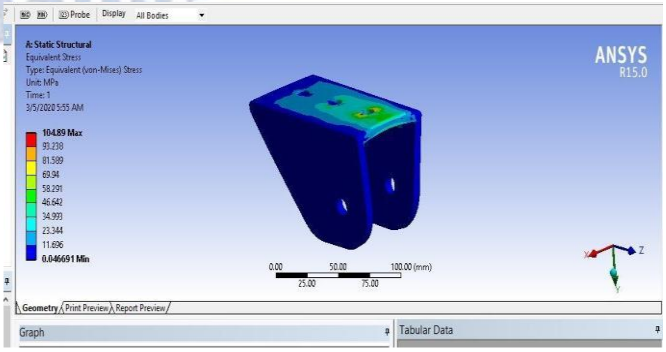

Figure 26: Equivalent stress of structural steel at 2500N

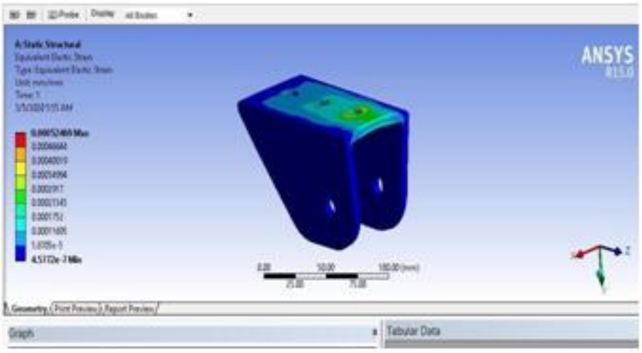

Figure 27: Equivalent elastic strain of structural steel at 2500N

Table 2: Results in Ansys for Material H.C.S

PARAMETERS	MAX LOAD AT 4500N	MAX LOAD AT 3500N	MAX LOAD AT 2500N
Total deformation	0.1789mm	0.13919mm	0.099424mm
Max Equivalent Stress	229.79 MPa	178.72 MPa	127.66 MPa
Max equivalent strain	0.000973	0.00075747	0.0005410

Table 3: Results in Ansys for Material Alloy Steel

PARAMETERS	MAX LOAD AT 4500N	MAX LOAD AT 3500N	MAX LOAD AT 2500N
Total deformation	0.16899mm	0.13144mm	0.093886mm
Max Equivalent Stress	146.9Mpa	114.25Mpa	81.61Mpa
Max equivalent strain	0.00074253	0.000577	0.00041251

Table 4: Results in Ansys for Material Structural Steel

PARAMETERS	MAX LOAD AT 4500N	MAX LOAD AT 3500N	MAX LOAD AT 2500N
Total deformation	0.17379mm	0.13517mm	0.093886mm
Max Equivalent Stress	188.8Mpa	146.84Mpa	104.89Mpa
Max equivalent strain	0.000944	0.00073456	0.00052469

VI. CONCLUSION

This analysis is carried out between different materials to find the total deformation and maximum equivalent stress at different load conditions. From the analysis, it is clear that alloy steel induces less equivalent stress, total deformation and maximum equivalent strain when compare to high carbon steel and structural steel.

From the above results we can say that alloy steel is the best material which is capable of withstanding stresses that are developed in the leaf spring bracket rather than conventional steels which are used to manufacture leaf spring bracket.

VII. FUTURE SCOPE

There is a wide scope for future work in this area now a day's alloy steels are best suitable for many applications .hence in future manufacturing leaf spring brackets with alloy steels will significantly increases its life time Experimental analysis can be carried forward and life cycle of the object can be studied.

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