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Modelling and Analysis of leaf spring for light motor vehicle

[1] Stalin B, [2] Shashi Kiran P, [3] Shreyas B, [4] Aravindan M R, [5] Sampath A
Department of Mechanical Engineering,
DR. Thimmaiah Institute of Technology, Oorgaum Kolar Gold Fields, Karnataka-563120, India

Abstract: Leaf springs are the most generally used suspension component in Automobiles. leaf springs advantage compared with helical springs is the ends of the spring may be guided along a path as it deflects to act as a structural member in addition to absorbing energy which acts on suspension system. One the main functions of leaf springs is not only to support vertical load and also to isolate from road vibrations and other major factors like sudden impact loads or due to over load on vehicles, road irregularities leaf springs break or occurring cracks on the suspension component. It is subjected to number of load cycles leads to fatigue failures. Finite element method of analysis is used to determine the pay load and safe stress of the leaf spring and also to study the structures behavior under many conditions and comparison of results with different materials. solid works V16 is used for 3D modeling of leaf spring and analysis software ANSYS 15.0 is used for FEM analysis of leaf spring as FEM is an accurate, efficient and less time-consuming method of analysis. A leaf spring suspension configuration of light motor commercial vehicle is chosen for study and analysis.

Keywords: Leaf springs, solid works, ANSYS 15.0, FEM.

I. INTRODUCTION

Leaf springs are the most generally used suspension component in Automobiles A leaf spring is defined as elastic body, One the main functions of leaf springs are not only to support vertical load and also to isolate from road vibrations and when load is removed it returns to original shape. Leaf spring suspension system is energy absorbing device. Which absorbs vehicle vibrations, shocks and loads induced due to road irregularities by means of springs deflection, and the potential energy is stored in the leaf spring and then relieved slowly from the suspension component. The ability to store and absorb amount of strain energy ensures the comfortable suspension systems. Semi-elliptic leaf springs are most commonly used for suspension component in light motor and heavy commercial vehicles. For cars also, these are widely used in rear suspension system.

Leaf spring suspension consists of a number of leaves called blades or Leaves. The number of blades is varying in different length. The blades are usually given an initial curvature length or cambered so that will tend to straighten under the many load conditions. The master blade has eyes on its ends. This blade is called main or master leaf, the remaining blades are called graduated leaves of suspension system.

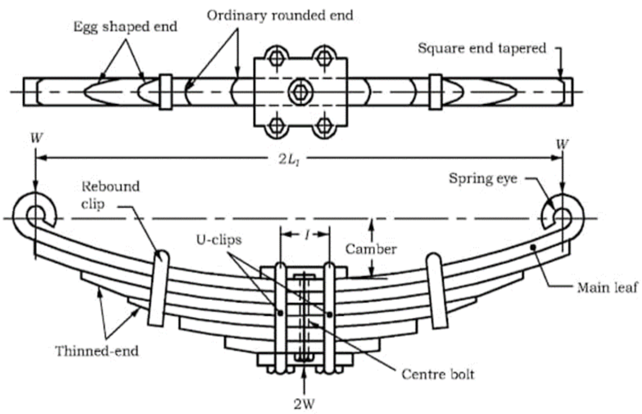

Fig 1: Schematic of leaf spring

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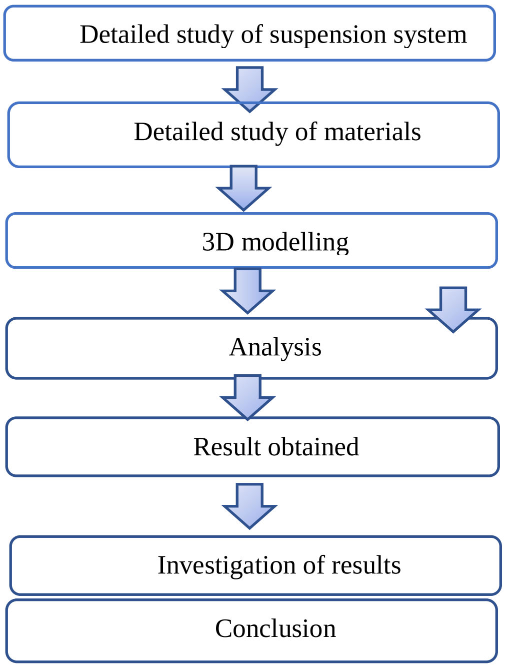
The leaf spring blades are bound together by means of steel straps. The spring is mounted on the axle of the vehicle mostly used for rear suspension. The total vehicle load is rests on the leaf spring suspension system. The front end of the leaf spring is connected to the frame with pin joint, while the rear end of the leaf spring component is connected with shackle pin. The shackle is the flexible link which connects between leaf spring rear eye and frame. Most generally used in light motor and heavy duty light commercial vehicles.

1.1 CONSTRUCTION OF LEAF SPRING

- In automobiles most commonly used leaf spring is Semi-Elliptical.
- The leaf spring is constructed in the form of number plates or leaf. Which is different in length.
- The main or master leaf is the lengthiest leaf and other leaves are called graduated.
- In clamping of leaf spring suspension to Axle U-bolt is used.
- To hold the leaf springs together Rebound clips are used.
- fix the position of leaf spring to the wheel axle central clamp is used.

II. METHODOLOGY



III. MODELLING OF LEAF SPRING

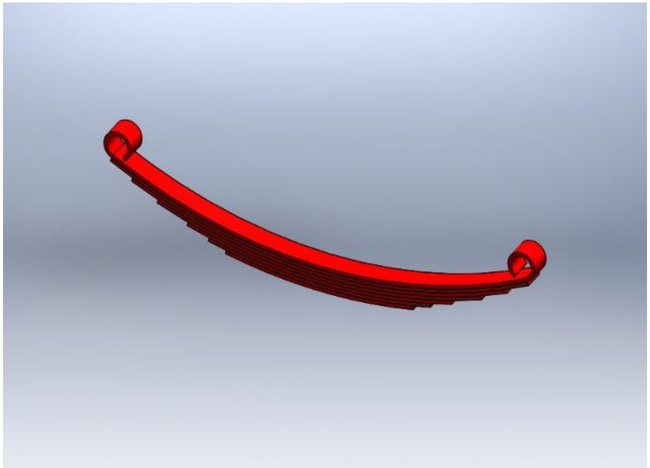


Fig 2: Modelling of leaf spring

IV. MESHED MODEL

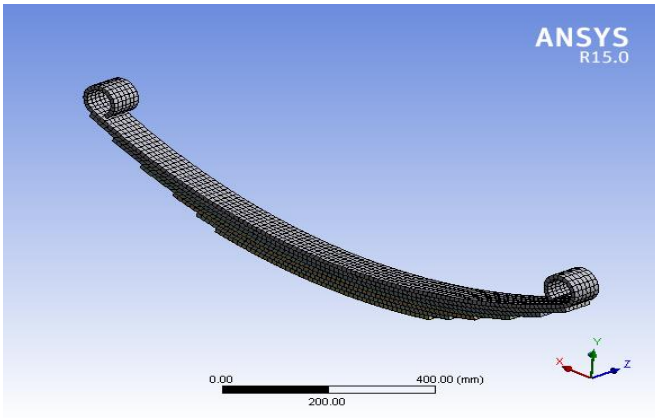


Fig 3: Meshed model

V. STATIC ANALYSIS OF LEAF SPRING

The static analysis is performed using ANSYS 15.0 and the Iteration are shown in figure. Total three Iteration performed for Plain carbon steel Sae 1090 and Titanium Alloy Ti-6al-4v. And the different load applied are: 2000N,5000N,7300N Respectively.

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Number of Iterations for Plain carbon steel Sae 1090 and Titanium Alloy Ti-6al-4v are shown in figure.

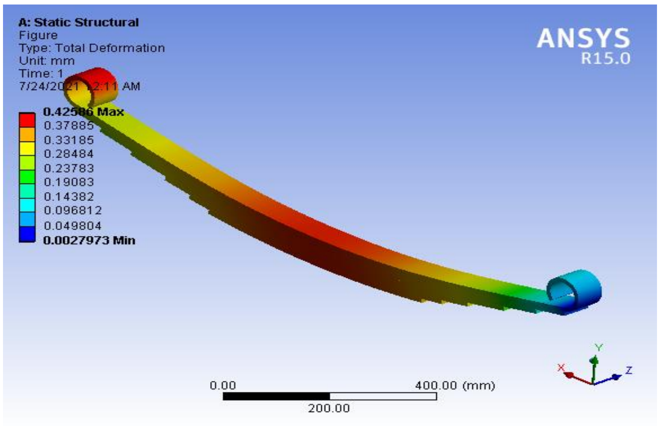

Fig 4: Iteration 1 Total deformation of plain carbon steel

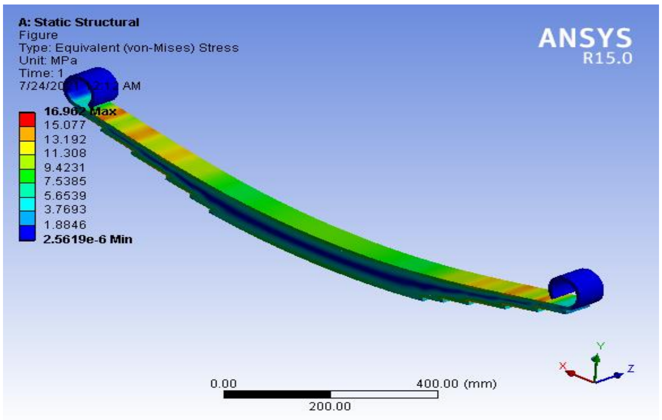

Fig 5: Iteration 1 Equivalent (Von mises) stress of Plain carbon steel

Load applied for Iteration-1 (2000N)

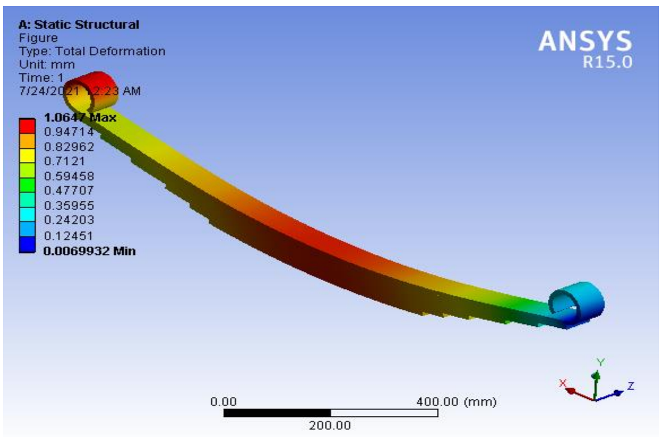

Fig 6: Iteration 2 Total deformation

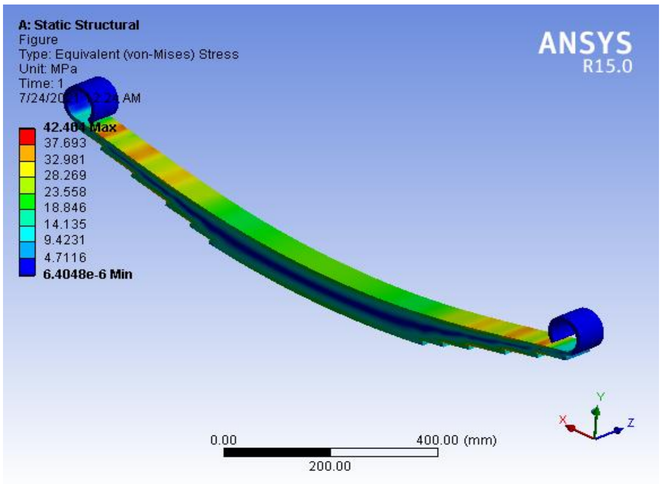

Fig 7: Iteration 2 Equivalent (Von mises) stress.

Load applied for Iteration -2 (5000N)

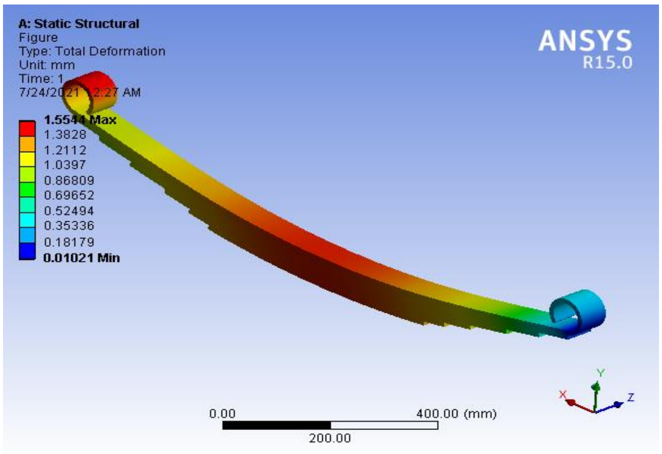

Fig 8: Iteration 3 Total deformation

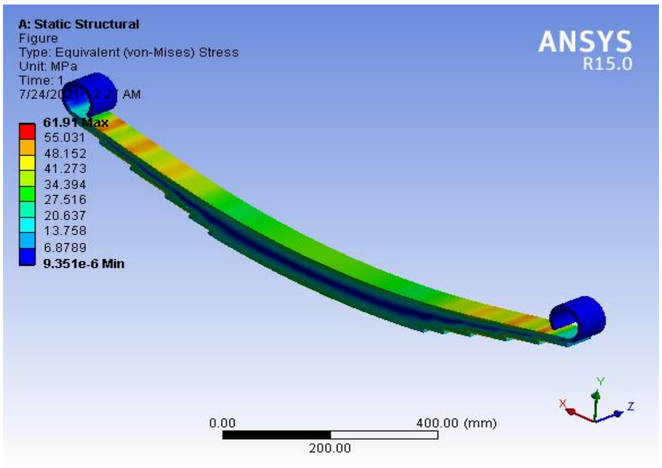

Fig 9: Iteration 3 Equivalent (Von mises) stress

Load applied for Iteration-3 (7300N)

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The total deformation and Equivalent (Von mises) stress for Plain carbon steel Sae 1090 for different loads are shown in below table-1.

Table -1 Total Deformation and Stress			
Material	Load N	Deformation Mm	Stress Mpa
Plain carbon steel Sae 1090	1000	0.21187	7.8994
	2000	0.42373	15.779
	3000	0.6356	23.698
	4000	0.84747	31.597
	5000	1.0593	39.497
	6000	1.2712	47.396
	7000	1.4831	55.296
	7300	1.5466	57.666

Table -1 Total Deformation and Stress

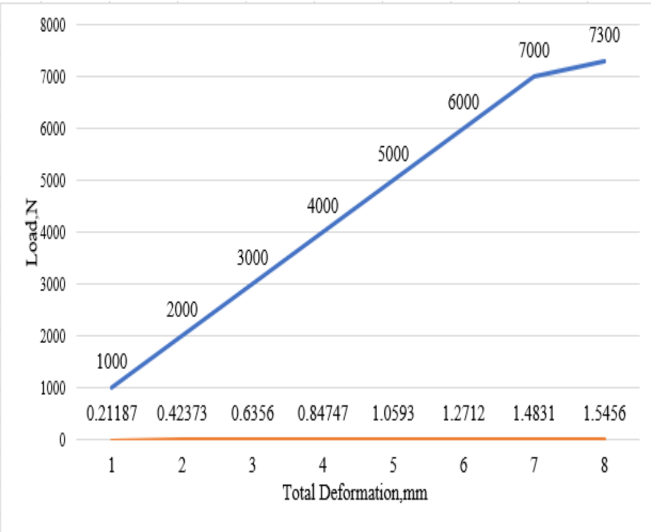

Chart-1 Load vs Total deformation

Chart 1 shows the total deformation and Equivalent (Von mises) stress for different load condition of plain carbon steel.

5.1 TOTAL DEFORMATION AND EQUIVALENT STRESS FOR TITANIUM ALLOY TI-6AL-4V

Number of Iteration three for Titanium Alloy Ti-6al-4v are shown in figure.

Load applied for three iterations are: 2000N,5000N,7300N.

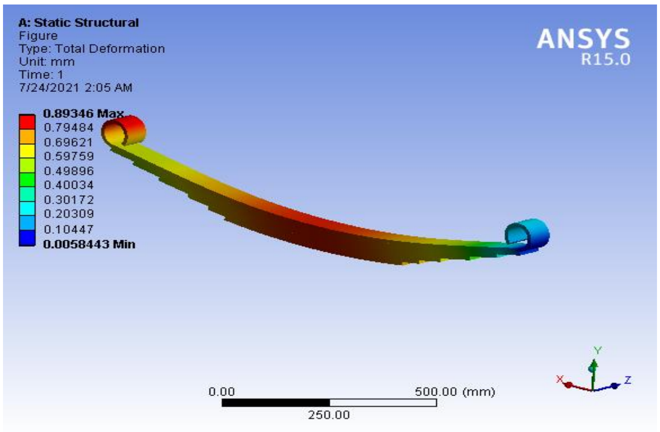

Fig 10: Iteration 1 Total Deformation of Titanium Alloy Ti-6al-4v

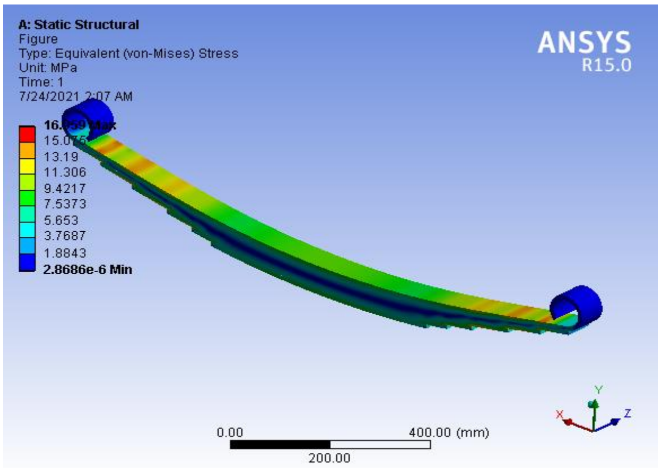

Fig 11: Iteration 1 Equivalent (Von mises) stress Titanium Alloy Ti-6al-4v

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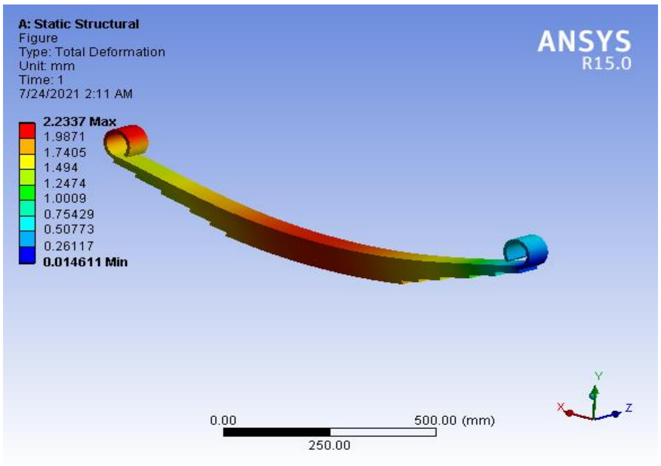

Fig 12: Iteration 2 Total Deformation of Titanium Alloy Ti-6al-4v

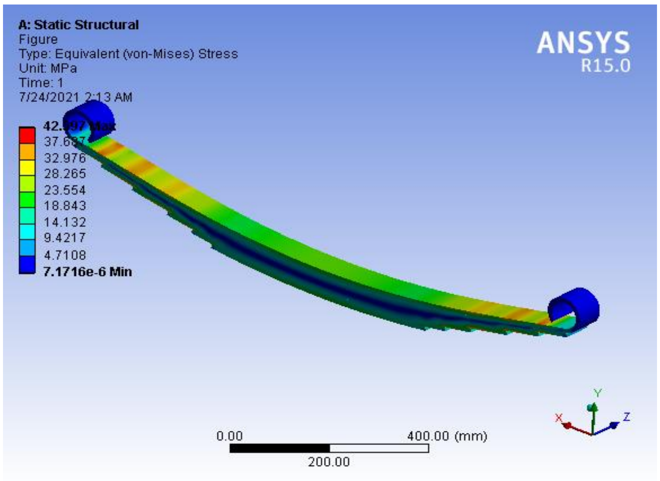

Fig 13: Iteration 2 Equivalent (Von mises) stress Titanium Alloy Ti-6al-4v

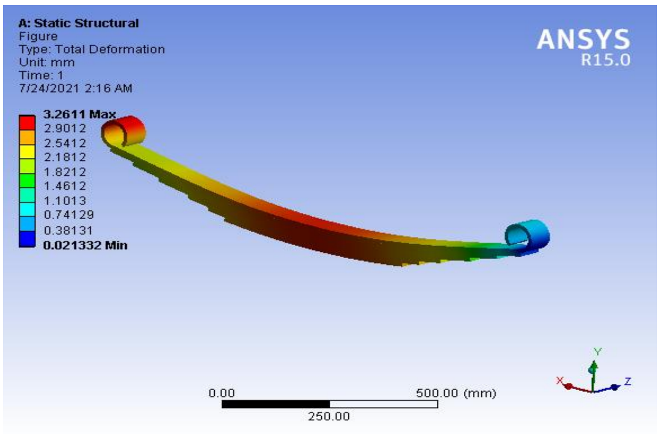

Fig 14: Iteration 3 Total Deformation of Titanium Alloy Ti-6al-4v

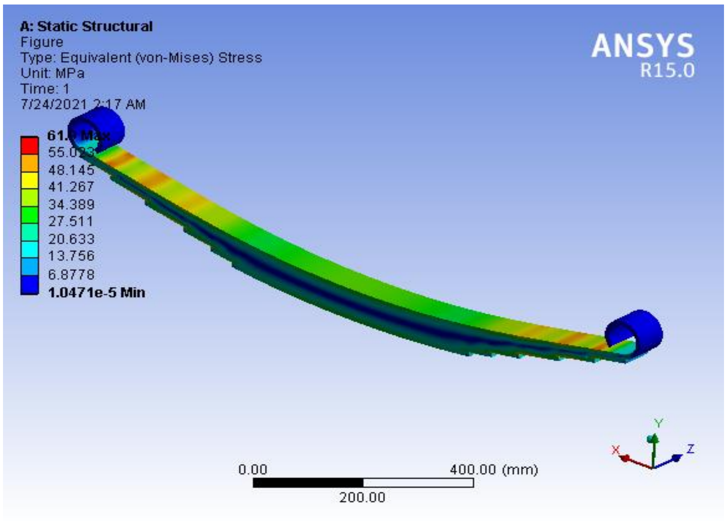

Fig 15: Iteration 3 Equivalent (Von mises) stress Titanium Alloy Ti-6al-4v

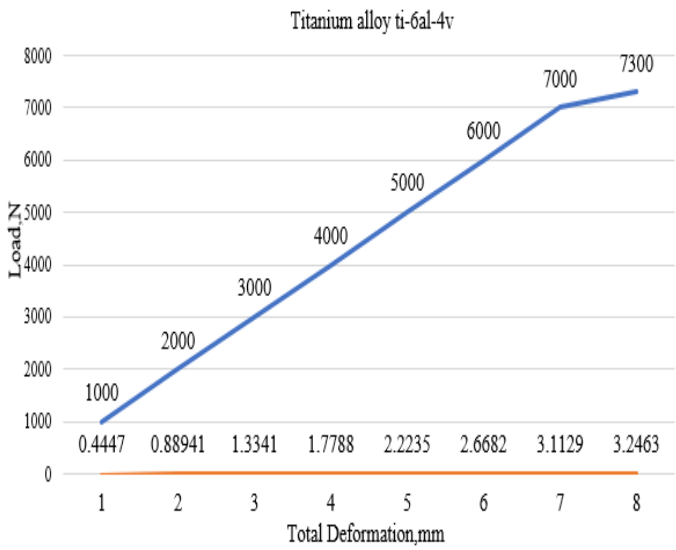

Chart 2: Total deformation

The below table shows total deformation and equivalent (von mises) stress for Titanium Alloy Ti-6al-4v with different loads.

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VI. RESULTS AND DISCUSSION

- Analysis and results: leaf spring modelling are done using solid works V16 and it is imported to Ansys and then it is subjected to different load conditions and changes like deformation, equivalent von mises stress.
- Deformation will be taken as graphs and Ansys results we analyse the variations from values shown by Ansys.
- The results are compared with parameters of both leaf spring and composite leaf spring. Some of the Ansys and tabular results are shown.

Table-3: Comparison of Results

Materials	Load N	Deformation mm	Stress MPa
Plain Carbon Steel Sae 1090	7300max	1.5466	57.666
Titanium Alloy Ti-6al-4v	7300max	3.2463	57.202

The table shows Comparison of results for Plain Carbon Steel Sae 1090 and Titanium Alloy Ti-6al-4v. And variations of results for both materials which is tabulated in above table.

VII. CONCLUSION

Analysis of leaf spring with different material shows that titanium alloy ti-6al-4v shows less stress for a particular load as compared to conventional plain carbon steel sae 1090 material.
Since the deformation of titanium alloy ti-6al-4v material is high compared to plain carbon steel hence it is concluded plain carbon steel shows better results compared with titanium alloy.

Table -2 Total Deformation and Stress

Material	Load N	Deformation mm	Stress Mpa
	1000	0.4447	7.8359
Titanium alloy ti-6al-4v	2000	0.7912	15.672
	3000	1.3341	23.508
	4000	1.7788	31.343
	5000	2.2235	39.179
	6000	2.6682	47.015
	7300	3.2463	57.202

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