Static Structural Simulation Analysis of Leaf Spring using Ansys Workbench

Arun Prakash, Devendra Singh, Ajay Kumar Sharma

Abstract: The leaf springs are different spring styles used for automotive suspension systems. In addition to the use of energy absorption equipment, the ends of the spring can be pointed in a certain direction as it deflects as a structural function. Not primarily supporting vertical loads but isolating road-induced vibration are the principal feature of leaf spring. The present research aims at studying the safe load of the leaf spring, showing how easily an easy, safe driving speed is achieved. A standard TATA-407 light commercial vehicle leaf spring configuration is chosen. Finite element analysis for safe stresses and pay loads has been done. Conventional materials and alternative materials in spring construction used in the present work have been studied.

Keywords : Leaf spring, Geometric modeling, Static analysis, Leaf spring, Composite material, FEM, ANSYS, Solid work.

I. INTRODUCTION

Two important issues in nowadays are vehicle fuel efficiency and pollution gas control. The car industry is trying to produce new vehicles that can provide low-high performance in order to solve this issue. Fuel saving can be easily increased by reducing the weight of the vehicle. Weight reduction will mainly be accomplished by better products, design and manufacturing processes improved. Composite was a very good substitute material for traditional steel by achieving weight loss with sufficient improvement of mechanical properties. A spring is an elastic structure that decreases in size if the initial shape is to be put again. The leaf spring is the most important spring mechanism in the automotive suspension system. This absorbs vehicle shakes, shocks and loads and even damping functions by springing motion. In the form of potential energy, it consumes electricity. The capacity to withstand and store additional stresses increases the comfort of the suspension system. The most frequently used type of leaf spring in heavy and light motor vehicles is semi-elliptical. The spring consists of several steps called leaves, while the spring of a mono leaf is just one step away. The spring absorption ability is increased by the number of steps. A multiple leaf spring is used for heavy vehicles, while a single leaf spring is used for light vehicles.

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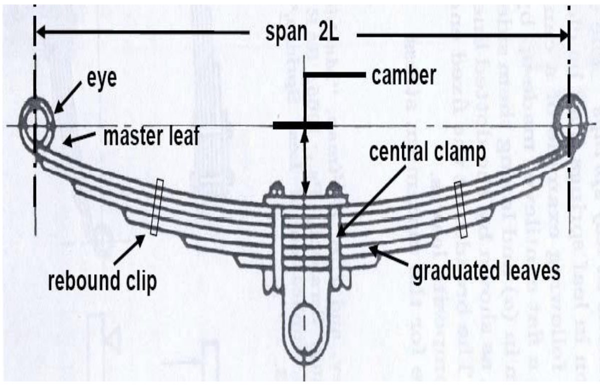


Figure 1: Schematic of Laminated semi-elliptic leaf spring

The coil is attached to the car's axle. On the leaf spring the whole car load is mounted. The front end of this spring is fixed to the frame with a single pin and a chocolate is placed in the back end of the spring. Shackle is the multi-faceted relation of the spring frame back to the leaf. The wheel rises and the spring is balanced when the car feels a reflection on the surface of the ground. It determines the duration of the spring leg. This longitudinal transition can not be accepted by the spring if the two ends are set. This adaptation to the length shake on one leg is thus a flexible partnership. The front eye of the leaf spring is open in any direction, while the rear eye is not open in X. This strange leg is tied to the shackle. The spring fluctuates and immediately passes to the load.

II. AIM AND OBJECTIVE OF RESEARCH

The multi-leaves spring was studied using finite element techniques, with seven leaves used for heavy industrial vehicles. Analysis is performed on the stress distribution and deflection characteristics in ANSYS 14.0 workbench. Each model is dynamically analyzed for four different materials with the same charge conditions.

The purpose of this research is to improve the collection of leaf spring materials. In Ansys, a static analysis is conducted in selected dimensions for this spring simulation and ANSYS 14.0 for selected architecture parameters. To reach the main study goal, the obtained findings are compared graphically. i.e. best leaf spring content collection.

III. REVIEW CRITERIA

This journal uses double-blind review process, which means that both the reviewer (s) and author (s) identities concealed from the reviewers, and vice versa, throughout the review process.

All submitted manuscripts are reviewed by three reviewer one from India and rest two from overseas. There should be proper comments of the reviewers for the purpose of acceptance/ rejection. There should be minimum 01 to 02 week time window for it.

IV. FINITE ELEMENT ANALYSIS

The experimental bridge structure Truss has been studied using ANSYS, a software product combined with commonly used engineering simulations, which provides a full group of products covering the entire spectrum of physics, allowing the use of almost many engineering replicas that are needed by the design process. The software package utilizes its tools to position a virtual product by a stringent test process, for example by measuring a beam for a considerable object below completely different loading condition. In a fast, safe way and with a large number of different contact algorithms, the ANSYS can perform advanced engineering analyses, mainly on loading times and non-linear materials. In this research, she investigates under static loading conditions under distinct modelling of the Truss bridge structure.

V. METHODOLOGY OF RESEARCH

The methodology of solution is chosen once the mathematical models are ready. A qualitative or quantitative dimension may be considered for the mathematical formulation of the problem. Mathematical formulations of the question are tested in qualitative analysis without clear resolution in qualitative analyses. Quantitative analytical methods, on the other hand, may be classified as theoretical, physical and computational methods. FEM research is usually performed in order to load the leaf spring statically.

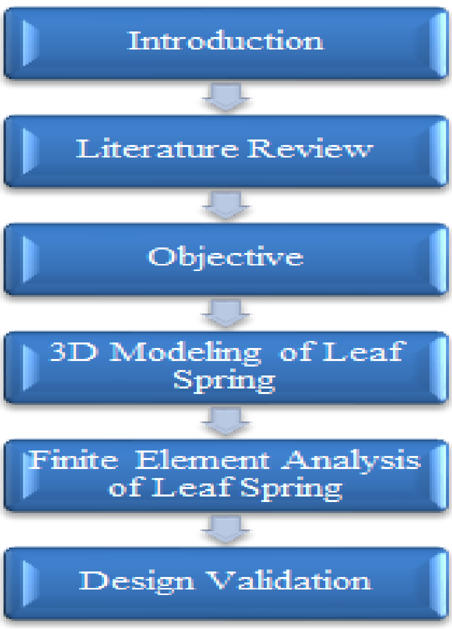


Figure 1: Flow Chart of Methodology

VI. MATERIAL SELECTION FOR LEAF SPRING

Structural steel is the main material for the leaf spring. This article has contrasted the result of structural steel, nickel molybdenum, Chrome vanadium steel, and plain carbon steel. As shown in Table 1, the properties of the materials used in the present research.

Table 1: Mechanical Properties of Materials

Properties	Unit	Structural steel	Chrome nickel molybdenum	Chrome vanadium steel	Plain Carbon Steel
Density	kg/m	7850	8440	7861.1	7800
Young's Modulus	Pa	2.00E+11	2.07E+11	1.90E+11	2.10E+11
Poisson's Ratio		0.3	0.325	0.29	0.28
Bulk Modulus	Pa	1.67E+11	1.97E+11	1.51E+11	1.59E+11
Shear Modulus	Pa	7.69E+10	7.81E+10	7.36E+10	8.20E+10
Tensile Yield Strength	Pa	2.50E+08	4.15E+08	6.20E+08	2.21E+08

VII. METHODOLOGY OF RESEARCH

For modeling and analysis, results are measured and compared in the latest work leaf spring of heavy-duty commercial vehicles. The 3D leaf spring is modelled with Ansys 14.0. The following table shows one of the leaf spring model measurements used for research.

Table 2: Dimensions of leaf spring

Sr. No.	Parameter	Value
1	Camber	80mm
2	Span	120 mm
3	Thickness	10 mm
4	width	50 mm
5	Number of leaves	5

A. Boundary Conditions

The figure indicates the limits of the leaf spring at the front and rear ends. The front end is fixed to the frame and can only be shifted in Z-direction. The rear end is related to the form of the frame and can be shifted in X-direction and Z-direction (rotation).

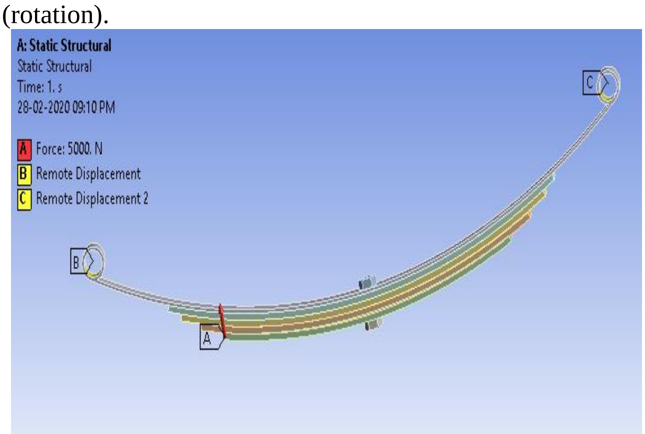


Figure 2: Boundary conditions applied on leaf spring

VIII. TEST RESULTS AND DISCUSSION

The deflection occurred in Leaf spring model is optimized with different materials and compared. Four types of materials (structural steel, Chrome nickel molybdenum, Chrome vanadium steel and Plain Carbon Steel) used in leaf spring designing which is used for heavy vehicle loading.

- **Leaf spring designed of Chrome Nickel Molybdenum Steel:**

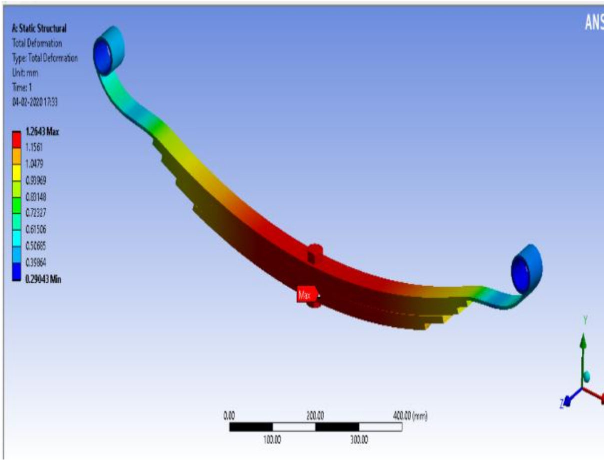


Figure 3: Total deflection of Chrome Nickel Molybdenum Steel

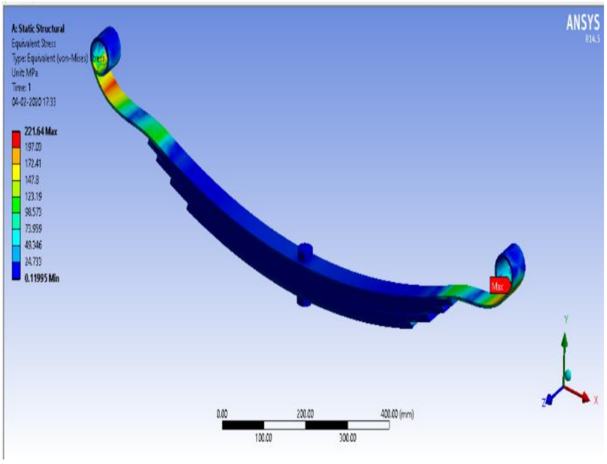


Figure 4: Stress generated of Chrome Nickel Molybdenum Steel

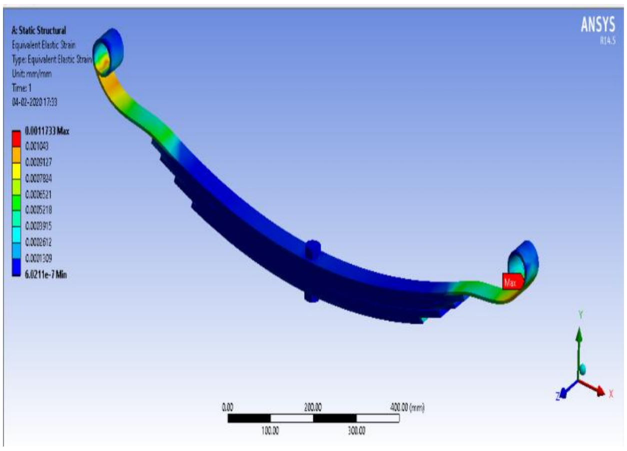


Figure 5: Strain in Chrome Nickel Molybdenum Steel

- **Leaf spring designed of Plain Carbon Steel:**

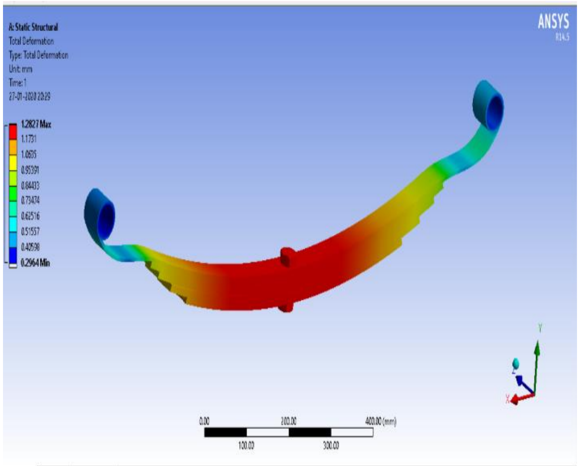


Figure 6: Total deflection of Plain Carbon Steel

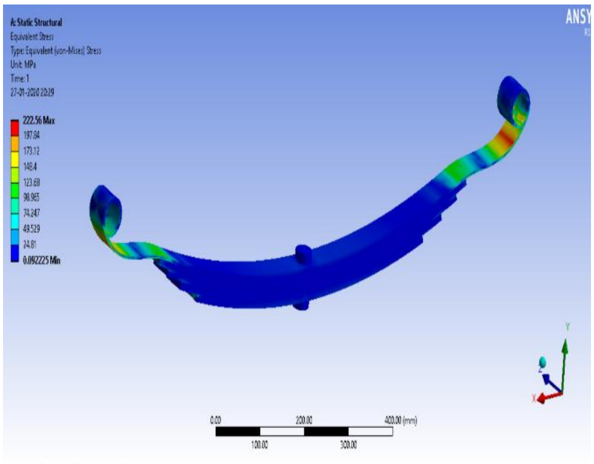


Figure 7: Stress generated of Plain Carbon Steel

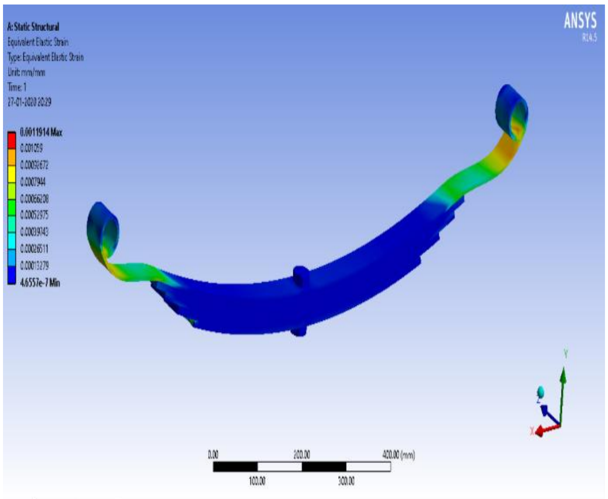


Figure 8: Strain of Plain Carbon Steel

- **Leaf spring designed of Chrome Vanadium Steel:**

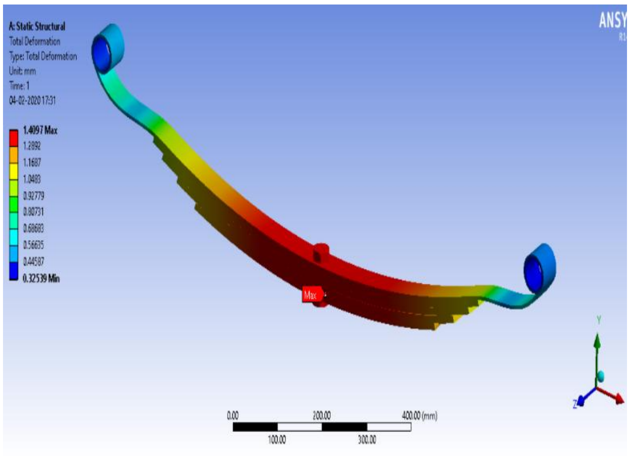


Figure 9: Total deflection of Chrome Vanadium Steel

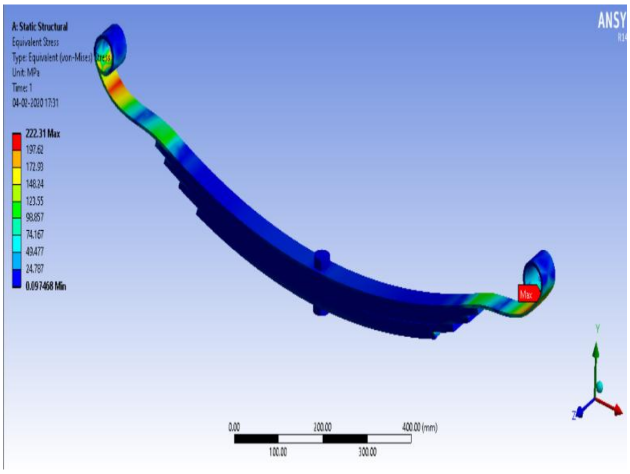


Figure 10: Stress generated of Chrome Vanadium Steel

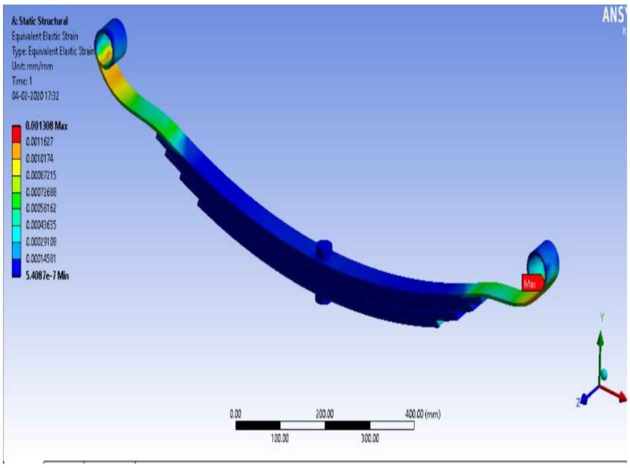


Figure 11: Strain of Chrome Vanadium Steel

- **Leaf spring designed of Structural Steel**

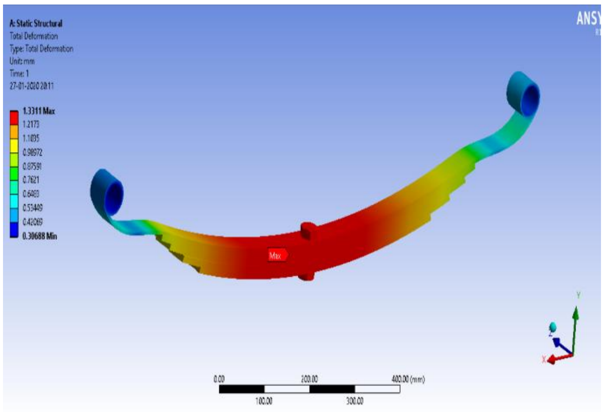


Figure 12: Total defection in leaf spring of Structural Steel

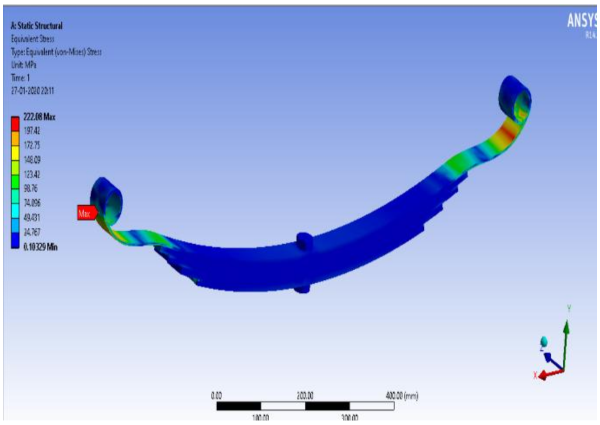


Figure 13: Stress generated in leaf spring of Structural Steel

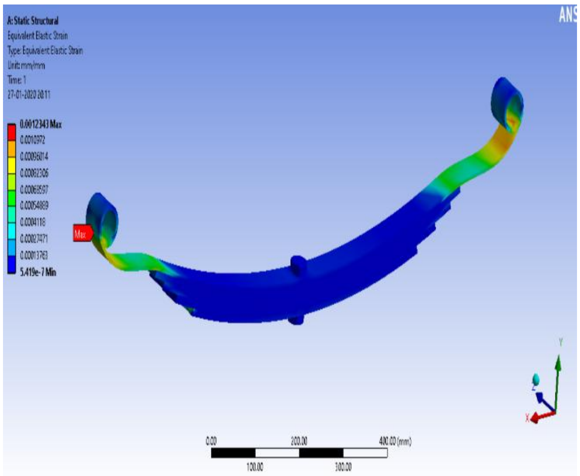


Figure 14: Strain in leaf spring of Structural Steel

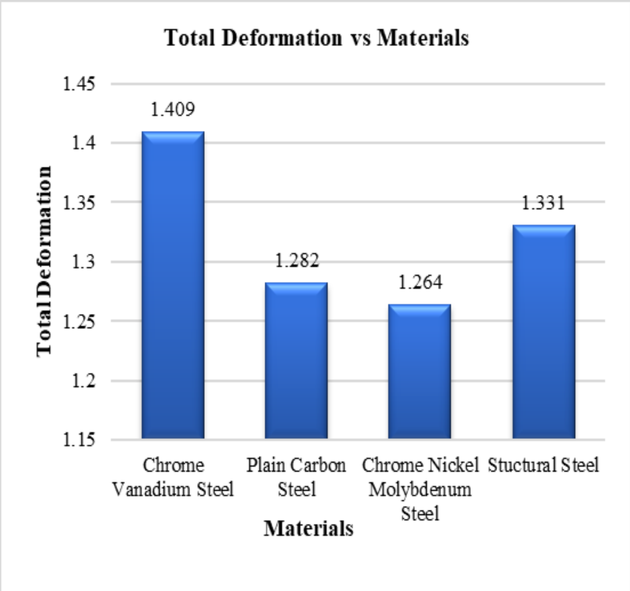
Table 3: Deflection on different material

Materials	Total Deformation	Safety Factor
Chrome Vanadium Steel	1.409	2.789
Plain Carbon Steel	1.282	0.991
Chrome Nickel Molybdenum Steel	1.264	1.872
Structural Steel	1.331	1.125

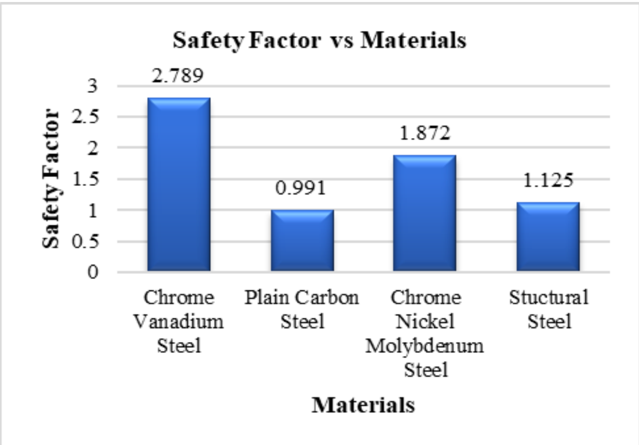
Table 4: Equivalent Stress on different material

Materials	Equivalent Stress	Strain
Chrome Vanadium Steel	222.31	1.31E-03
Plain Carbon Steel	222.56	1.19E-03
Chrome Nickel Molybdenum Steel	221.64	1.17E-03
Structural Steel	222.08	1.23E-03

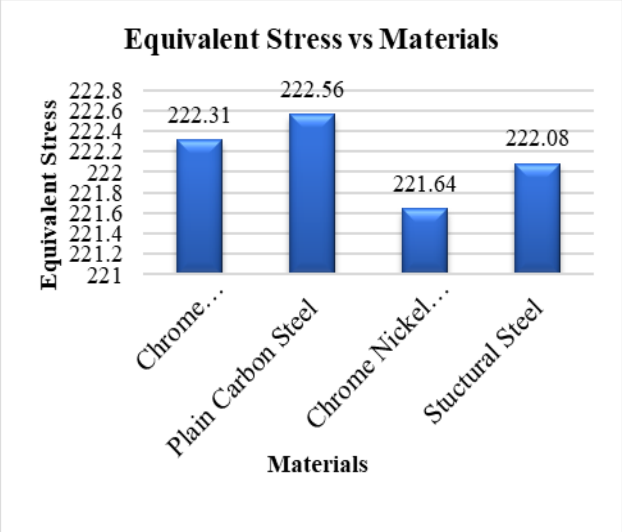
Using ANSYS Workbench 14.0, leaf spring is analyzed for static load for model with four different materials viz. structural steel, Chrome nickel molybdenum, Chrome vanadium steel and Plain Carbon Steel. The results obtained are plotted in graphical and tabular format.



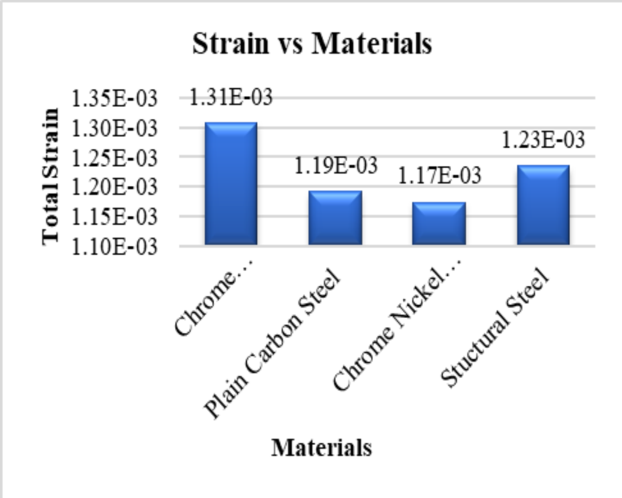
Graph 15: Comparison of deflection of leaf spring using different material



Graph 16: Comparison of safety factor of leaf spring using different material



Graph 17: Comparison of stress of leaf spring using different material



Graph 18: Comparison of strain of leaf spring using different material

IX. CONCLUSION

Ansys results of leaf spring model shows Maximum deformation of leaf spring found on chrome vanadium steel material i.e. 1.409 mm.

Minimum deformation found on Chrome Nickel Molybdenum Steel material i.e. 1.264 mm. So, we can say as per comparison of deformation that Chrome Nickel Molybdenum Steel material gives satisfactory results as comparison to others. Factor of safety of Chrome Nickel Molybdenum Steel material higher than plain carbon and structural steel material. stress developed in Chrome Nickel Molybdenum Steel material has lower remain to other materials.

So, Chrome Nickel Molybdenum Steel material having best optimum results in this study, so it is concluded as per investigation that Chrome Nickel Molybdenum Steel best stability in leaf spring design other than to plain carbon steel, structural steel, Chrome vanadium steel.

- Ansys workbench is used for 3d modeling of leaf spring. This method is more cost effective less time consuming then other methods of modeling.
- Leaf spring assembly file in IGES file format is exported to ANSYS 14.0 for analysis.
- ANSYS 14.0 is used for meshing and analysis of leaf spring. This method of analysis is more cost effective, efficient and less time consuming than other methods of solution.
- Static analysis of leaf spring for different material combination under similar loading condition has been done for all design cases.
- Results for selected parameters are obtained for all design cases of leaf spring.
- Total deformation, equivalent elastic strain, equivalent (Von-Mises) stress, strain energy and mass results have been analyzed for different material combination in different design cases of leaf spring.

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