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Analyze the Design of Leaf spring by Solid works and Ansys to Improve the Vehicle Performance

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ABSTRACT

The energy consumption and pollution gas control of cars are two major problems mostly in present era. The automotive industries are trying to build fresh vehicles that can provide high performance at low cost to meet this problem. The most effective way to improve fuel economy is to try to reduce the vehicle's weight. Using a better materials, improved design, and enhanced manufacturing processes can all help decrease mass. Metal alloys have become such a good substitute material for traditional steel due to improvements in mechanical properties and weight reduction. Due to its improved mechanical properties of composite materials, a variety of parts for automobiles can be replaced by composites. This material has higher elastic strength and hardness than steel materials. It has a higher strength-to-weight ratio as well. Thus, the leaf spring used for carrying out entire weight of the car is the best choice for replacing carbon steel with composite material from several components of one of the automotive components. The research has been carried out on the Mahindra Pickup model with the same dimensional geometry to reduce the weight Chromium-vanadium steel, nickel-chromium-molybdenum steel, silicon manganese steel, and tungsten chromium steel were chosen for the leaf spring because they are high strength and inexpensive materials with similar and geometric properties to the current leaf spring. On ANSYS 16.0.0, the study was carried out. In order to finalize the most acceptable material for real-time applications, a comparative analysis was performed between steel and steel leaf spring alloys in terms of strength and weight.

KEYWORDS

Leaf Spring, Suspension System, Composites &Alloys, Solid Works,ANSYS.

Introduction

To conserve natural resources and energy, automobile manufacturers have made weight reduction a top priority. The use of high-quality materials, design optimization, and increased manufacturing processes are the most appropriate ways to lose weight. [1].It is used in automotive industry because it reduces the unsprung weight of the vehicles. Unsprung elements of the vehicle are those that do not have their weight transferred to the suspension spring. The weight of the suspension springs and shock absorbers, as well as the assembly of the wheels and axles, were included in the calculation. [2].The advantages of a leaf spring over a helical spring are that the finishes of the springs are guided along a positive way to go about as an underlying part notwithstanding the stun engrossing gadget. This is the reason, in various vehicles, leaf springs are still broadly used to bear hub loads, sidelong loads, and brake force in the suspension framework. [3]. Springs are common vehicle suspension parts that help to limit vertical movements, effects, and knocks caused by street irregularities while also providing a comfortable ride. In car suspension systems, a leaf spring, particularly the longitudinal type, is a dependable and long-lasting component. [4]. The benefit of the Leaf spring over the helical spring is that the finishes of the springs are guided along a positive way to go about as an underlying part notwithstanding the stun engrossing instrument. [5]. The region of leaf spring suspension ought to be founded on improving the vehicle's suspensions for comfort riding. Because it accounts for 10 to 20% of unsprung weight, the suspension leaf spring is one of the most likely candidates for auto weight reduction. Because it accounts for 10 to 20% of unsprung weight, the suspension leaf spring is one of the most likely candidates for auto weight reduction. It's regular information that springs are designed to withstand stuns. [6]. The leaf spring can assimilate

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vertical vibrations and effects brought about by street inconsistencies by shifting spring diversion, permitting the expected energy to be put away as strain energy in the spring and afterward gradually delivered. Subsequently, expanding the energy stockpiling limit of a leaf spring guarantees a more consistent suspension framework. [7]. It is basic information that springs are intended to assimilate and store energy prior to delivering it. As an outcome, when developing springs, the material's strain energy turns into a huge concern. [8]. Composites have a higher solidarity to-weight proportion, unrivaled exhaustion strength, great consumption opposition, smoother ride, higher common recurrence, and different benefits over steel for leaf springs. [9]. When the composites are ideal for leaf springs with a high explicit solidarity to weight proportion, internal damping inside the composite material leads to improved retention of energy created inside the material. Composite springs have a mass decrease advantage since they are multiple times more grounded than traditional steel springs. After the contextual investigation is completed, there is some difficulty in determining the mass of the primary steel leaf spring is similarly high. The diversion credits are poor in the main to primary steel and helpless ride attributes of constant commotion and grating. Four fundamental types of leaf spring frameworks are: Spring multi-leaf, Mono spring with leaves, Single-leaf Parabolic, Leaf Spring Fiberglass.

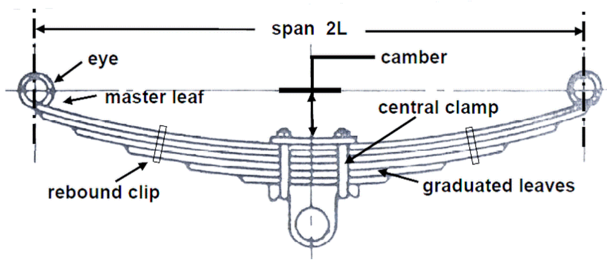

Fig. 1. Basic of leaf spring model
Source:https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.researchgate.net%2Ffigure%2FSemi-elliptic-leaf-spring-2_fig1_329639883&psig=AOvVaw2dh5WS0Ai_9iVS5Yic6qu8&ust=1614261186332000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCIivsemKhO8CFQAAAAAdAAAAABAD

Methodology

We collect the information such as materials suitable for leaf spring and obtain the material's mechanical properties and make a leaf spring design with the appropriate dimensions. Analyze the leaf spring with the different material, then compare the different materials and achieve the desired material result.

Modelling and Analysis

The leaf spring is taken from large trucks for modelling and study. Leaf springs are modelled in 3D using SOLIDWORKS 2016. One of the leaf spring models used in the analysis is depicted in the diagrams below.

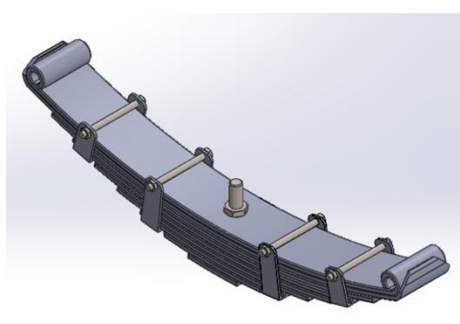

Fig. 2. Analysis ofthe multi leaf spring model

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Analysis of Structural Steel Leafspring

STRUCTURAL STEELS are iron-based alloys containing at least approximately 12% Cr, the quantity required to prevent rust from developing in the unpolluted atmosphere. There are some stainless steels that contain more than 30% Cr or only about 50% iron. Through the creation of a transparent and adherent chromium-rich oxide film, they attain the stainless features. In the presence of air, this oxide forms and cures it.Nickel, manganese, molybdenum, selenium, titanium, copper, sulfur, aluminum, niobium, and selenium are other materials included to strengthen unique features. In some grades, carbon is normally present in amounts ranging from less than 0.03 percent to over 1.0 percent.

Properties of Outline Row 3: Structural Steel

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	7850	kg m^-3		
3	Isotropic Secant Coefficient of Thermal Expansion				
6	Isotropic Elasticity				
7	Derive from	Young's Modulus a...			
8	Young's Modulus	2E+11	Pa		
9	Poisson's Ratio	0.3			
10	Bulk Modulus	1.6667E+11	Pa		
11	Shear Modulus	7.6923E+10	Pa		
12	Field Variables				
13	Temperature	Yes			
14	Shear Angle	No			
15	Degradation Factor	No			
16	Alternating Stress Mean Stress	Tabular			
20	Strain-Life Parameters				
28	Tensile Yield Strength	2.5E+08	Pa		
29	Compressive Yield Strength	2.5E+08	Pa		
30	Tensile Ultimate Strength	4.6E+08	Pa		
31	Compressive Ultimate Strength	0	Pa		

Fig. 3. Properties of Structural Steel

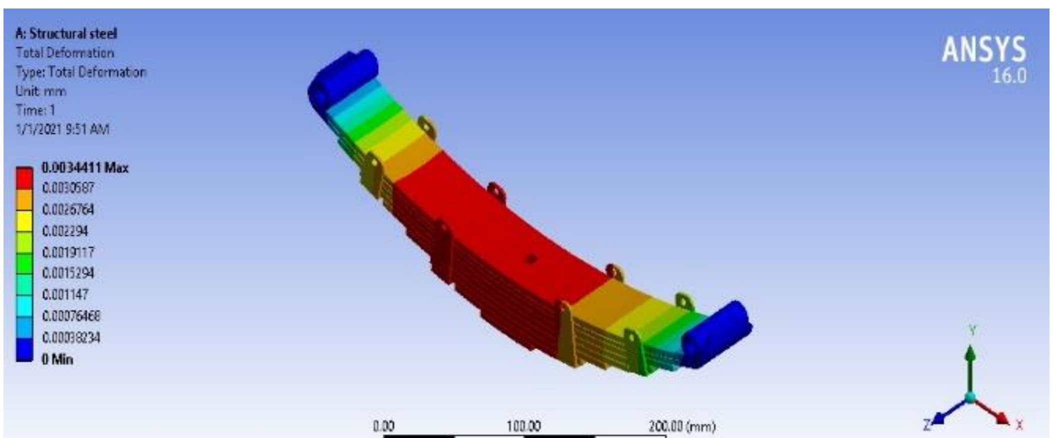

Fig. 4. Total Deformation

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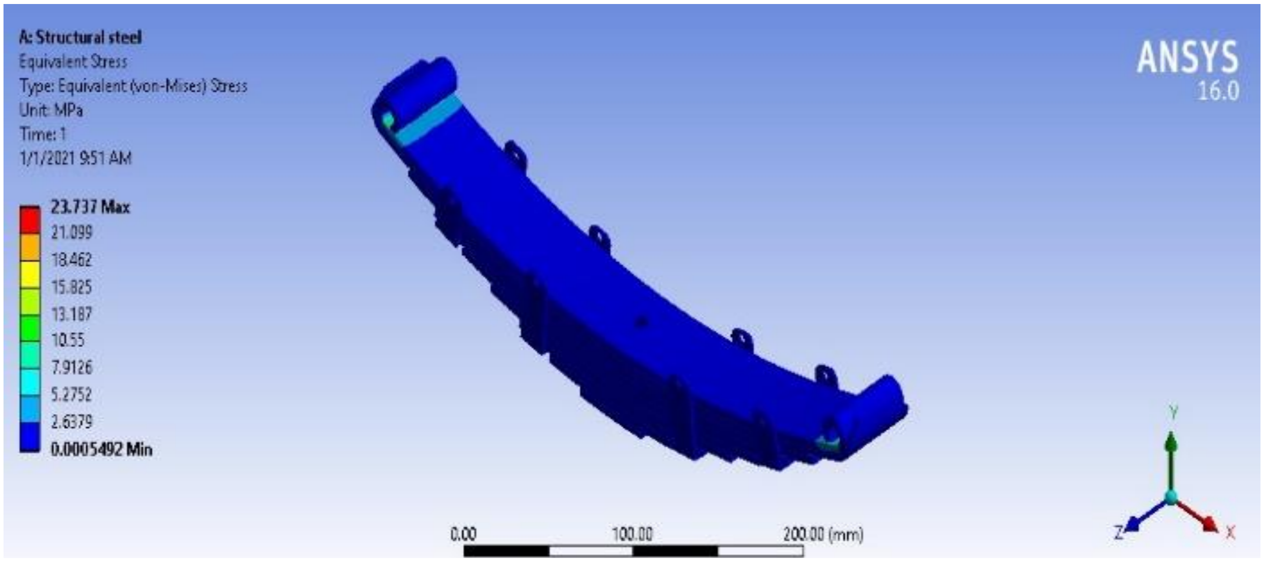

Fig. 5. Stress Distribution

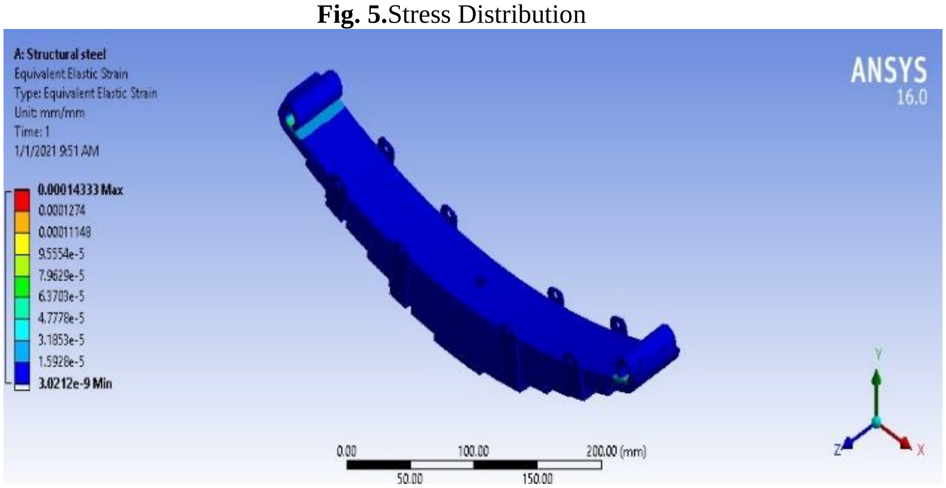

Fig.6. Strain Distribution

Analysis of Chromium Vanadium steel Leafspring

A common type of steel created by alloying chromium, carbon, vanadium, and other metals is chromium vanadium. For various industrial applications, SMSC supplies chromium vanadium springs. Due to their normal chemical composition, these springs give advantages of specific load tolerances, hardness, corrosion resistance, and stress-reliever characteristics. Therefore, these steel springs are used for applications with heavy impact loads and high tension. In high temperatures, these steel springs can also perform well. This alloy is produced in diverse proportions by combining chemicals. The percentage of each part will differ in accordance with the finished product's desired characteristics. The technical information below will assist you in understanding the structure and mechanical properties of this alloy.

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Properties of Outline Row 6: chromium-vanadium-steel

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	7.8	g cm^-3		
3	Isotropic Elasticity				
4	Derive from	Young's M...			
5	Young's Modulus	2.1E+11	Pa		
6	Poisson's Ratio	0.29			
7	Bulk Modulus	1.6667E+11	Pa		
8	Shear Modulus	8.1395E+10	Pa		
9	Field Variables				
10	Temperature	Yes			
11	Shear Angle	No			
12	Degradation Factor	No			
13	Tensile Yield Strength	9.4E+08	Pa		

Fig. 7. Properties of Chromium Vanadium Steel

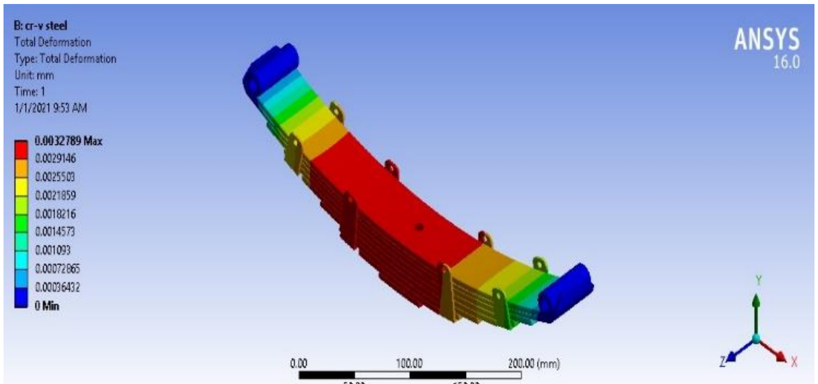

Fig. 8. Total Deformation

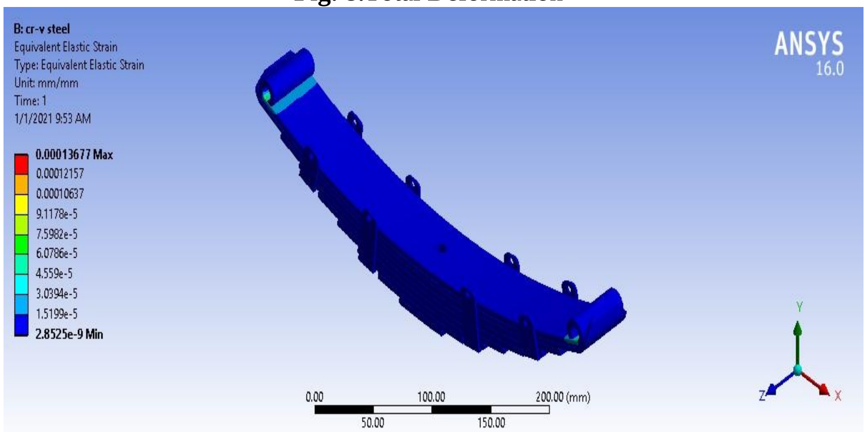

Fig. 9. Stress Distribution

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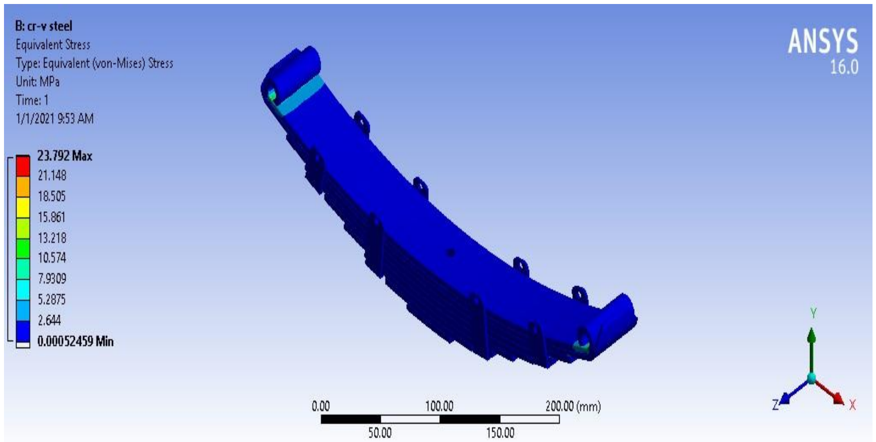

Fig.10. Strain Distribution

Analysis of Nickel Chromium Molybdenum Steel Leafspring

Alloy steels include multiple kinds of steels with compositions that surpass the limits set for carbon steels for B, C, Mn, Mo, Ni, Si, Cr, and Va. AISI four-digit numbers are designated by them. Nickel Chromium Molybdenum alloy steel has high toughness and strength. To achieve good welding characteristics, it has a low carbon content.

Properties of Outline Row 3: Nickel-Chromium-Molybdenum-Steel

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	8.8	g cm^-3		
3	Isotropic Elasticity				
4	Derive from	Young's Modulus an...			
5	Young's Modulus	5.4E+08	Pa		
6	Poisson's Ratio	0.28			
7	Bulk Modulus	4.0909E+08	Pa		
8	Shear Modulus	2.1094E+08	Pa		
9	Field Variables				
10	Temperature	Yes			
11	Shear Angle	No			
12	Degradation Factor	No			
13	Tensile Yield Strength	13.54	MPa		

Fig. 11. Properties of Nickel Chromium Molybdenum Steel

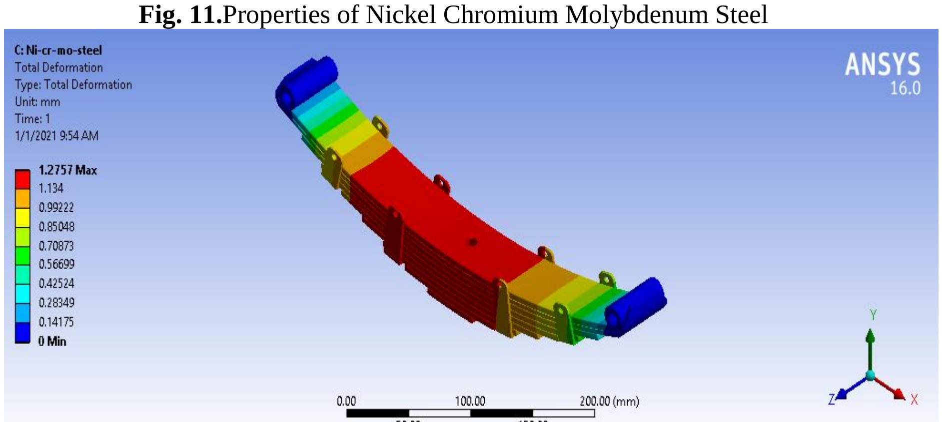

Fig. 12. Total Deformation

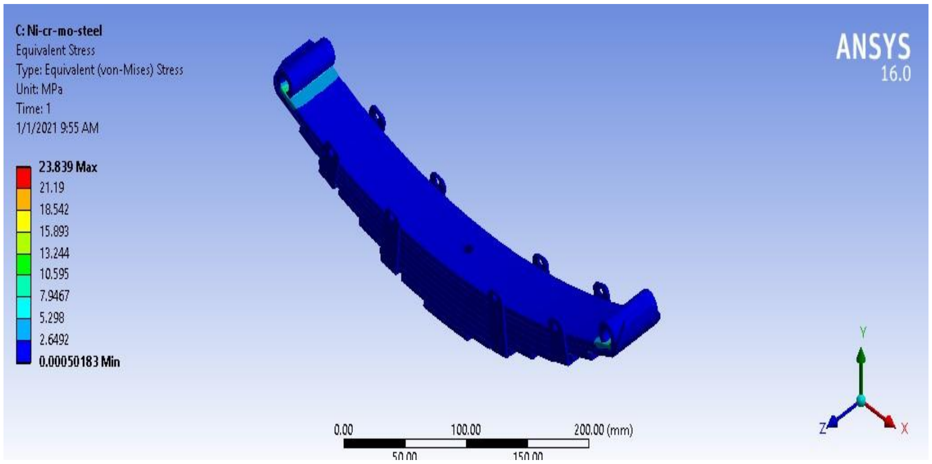

Fig. 13. Stress Distribution

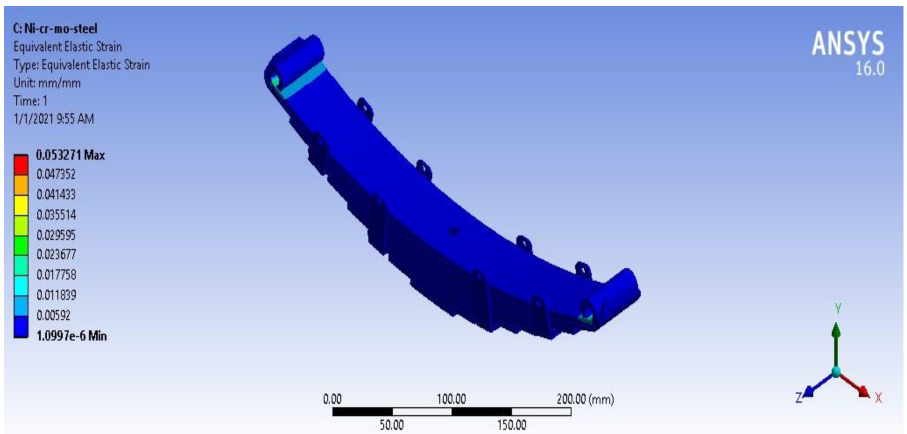

Fig.14. Strain Distribution

Analysis of Silicon Manganese Steel Leafspring

Steel would be a metal made of alloying iron with carbon and, because of its significant mechanical properties, is utilized in pretty much every industry. Its durability is joined with high strength and machinability, and assembling is similarly modest, making it a materials in new choice for most creators. The American Iron and Steel Institute (AISI) and the Society of Automotive Engineers (SAE) have made steel choice simpler by naming different steel grades with records that characterize metal combinations and general properties of a steel. This post will zero in on 9260 steel, a huge silicon composite spring steel with fantastic working properties. This article examines the synthetic piece, actual qualities, and details of 9260 steel to assist the peruse with choosing whether it is a decent material decision for their task.

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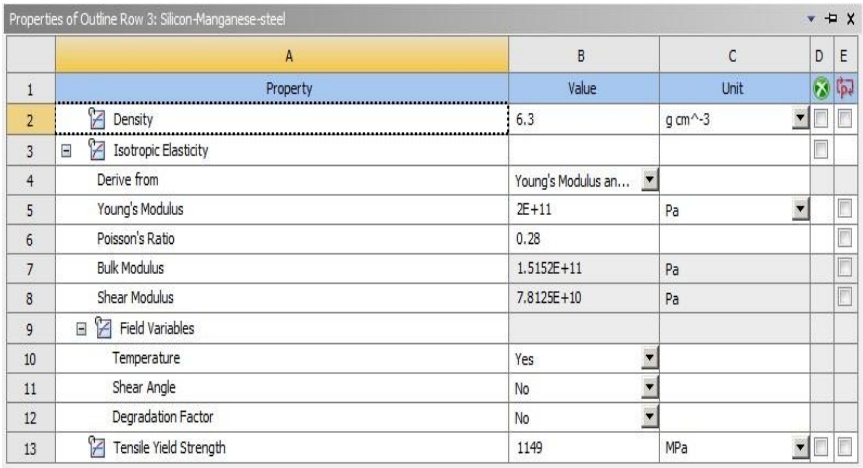

Properties of Outline Row 3: Silicon-Manganese-steel

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	6.3	g cm^-3		
3	Isotropic Elasticity				
4	Derive from	Young's Modulus an...			
5	Young's Modulus	2E+11	Pa		
6	Poisson's Ratio	0.28			
7	Bulk Modulus	1.5152E+11	Pa		
8	Shear Modulus	7.8125E+10	Pa		
9	Field Variables				
10	Temperature	Yes			
11	Shear Angle	No			
12	Degradation Factor	No			
13	Tensile Yield Strength	1149	MPa		

Fig. 15. Properties of Silicon Manganese Steel

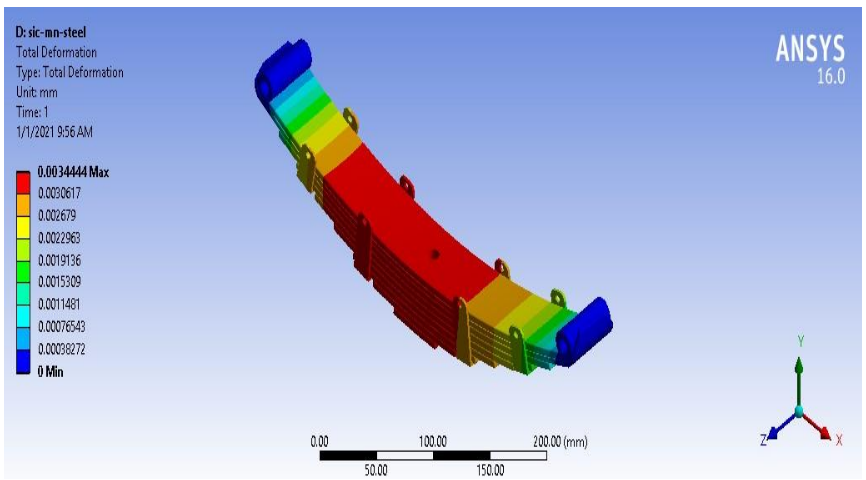

Fig. 16. Total Deformation

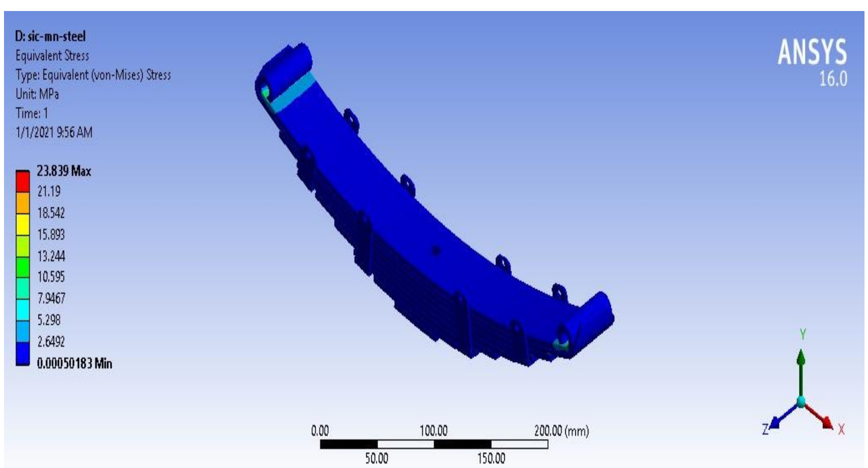

Fig. 17. Stress Distribution

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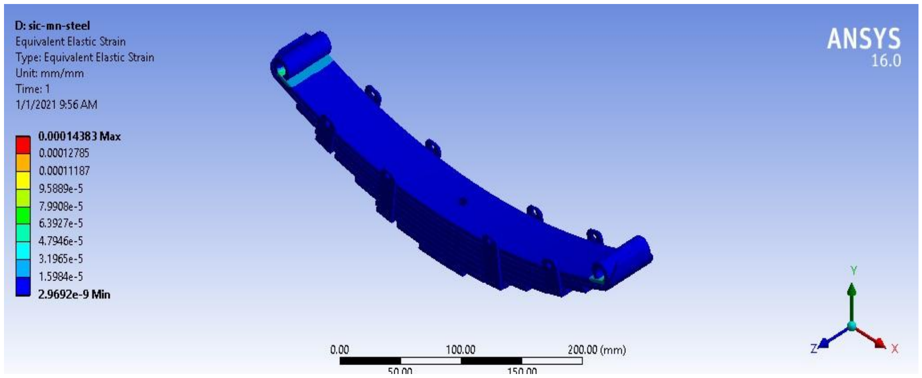

Fig. 18. Strain Distribution

Analysis of Tungsten Chromium Steel Leafspring

High carbon prepares are cold-work device prepares partitioned into three subgroups: oil-solidifying prepares, high-carbon prepares, high-chromium prepares, and air-solidifying prepares. Solidifying of oil Types O1, O2, O6, and O7 cold-work prepares are additionally named class O prepares. Steel that has been cold-worked Chromium, manganese, and tungsten make up Type O1 oil-solidifying, which is moderately reasonable. The type of O1 is portrayed in detail in the datasheet that accompanies it.

Properties of Outline Row 3: Structural Steel

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	7850	kg m^-3		
3	Isotropic Secant Coefficient of Thermal Expansion				
6	Isotropic Elasticity				
7	Derive from	Young's Modulus an...			
8	Young's Modulus	2E+11	Pa		
9	Poisson's Ratio	0.3			
10	Bulk Modulus	1.6667E+11	Pa		
11	Shear Modulus	7.6923E+10	Pa		
12	Field Variables				
13	Temperature	Yes			
14	Shear Angle	No			
15	Degradation Factor	No			
16	Alternating Stress Mean Stress	Tabular			
20	Strain-Life Parameters				
28	Tensile Yield Strength	2.5E+08	Pa		
29	Compressive Yield Strength	2.5E+08	Pa		
30	Tensile Ultimate Strength	4.6E+08	Pa		
31	Compressive Ultimate Strength	0	Pa		

Fig. 19. Properties of Tungsten Chromium Steel

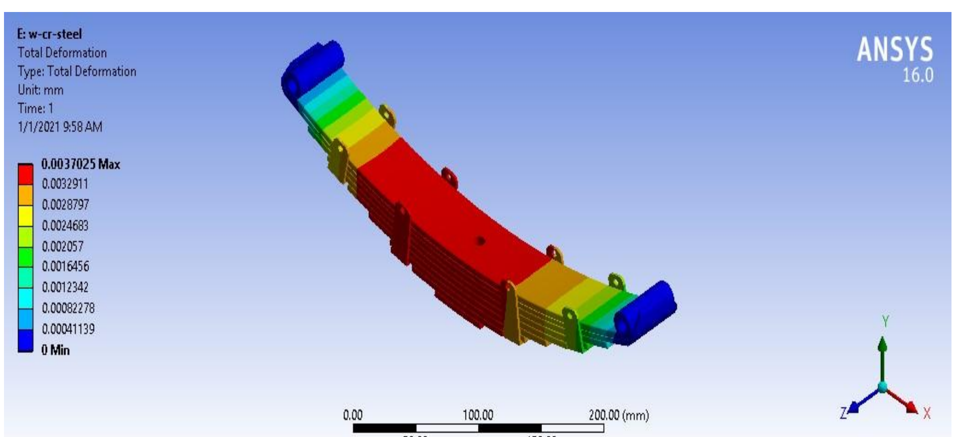

Fig. 20. Total Deformation

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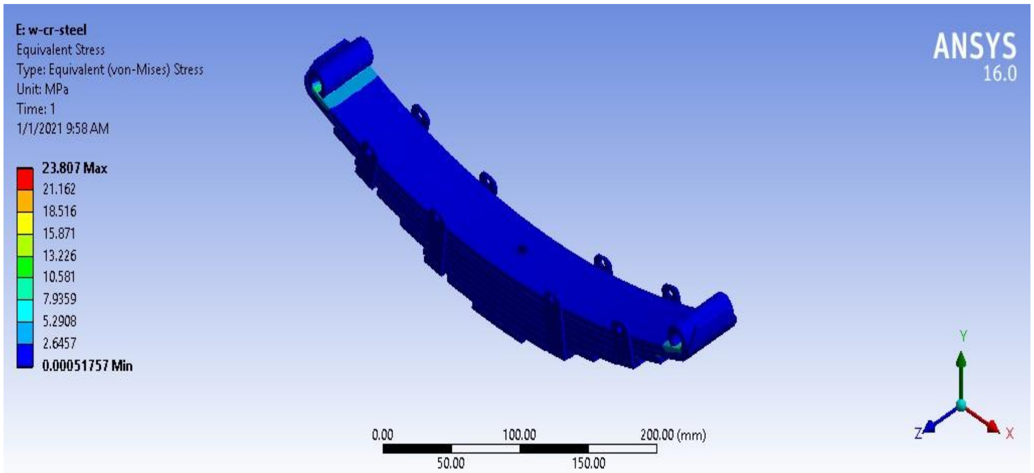

Fig. 21. Stress distribution

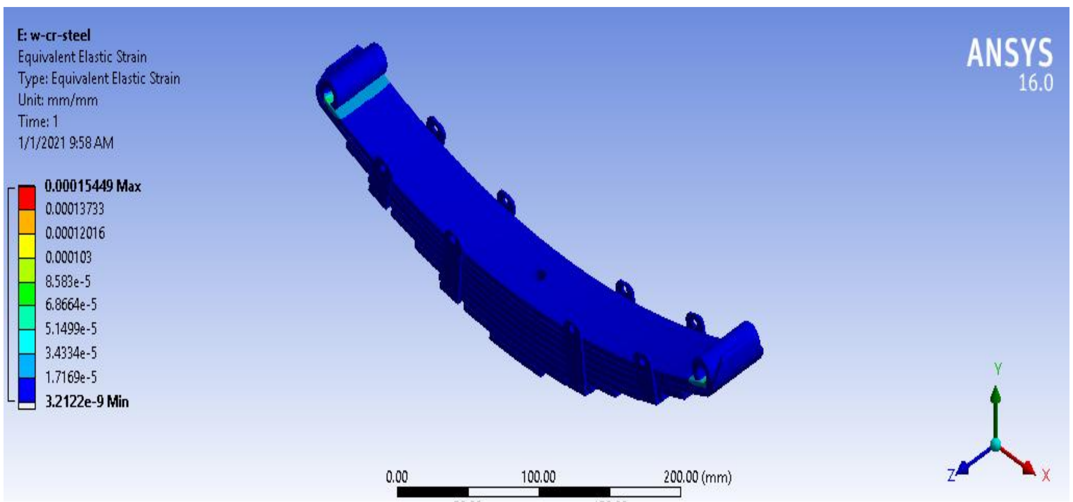

Fig. 22. Strain Distribution

Result

Table 1. Results of analyzed materials

MATERIAL	TOTAL DEFORMATION(MM)		STRESS (MPa)		STRAIN		MASS (KG)
	MIN	MAX	MIN	MAX	MIN	MAX	
STRUCTURAL STEEL	0	3.4E-3	5.49E-4	23.73	3.02E-9	1.43E-4	4.45
CHROMIUM VANADIUM STEEL	0	3.27E-3	5.24E-4	23.79	2.85E-9	1.36E-4	4.42
NICKEL CHROMIUM MOLYBDENUM STEEL	0	1.27	5.01E-4	23.83	1.09E-6	0.053	4.99
SILICON MANGANESE STEEL	0	3.44E-3	5.01E-4	23.83	2.96E-9	1.43E-4	3.57
TUNGSTEN CHROMIUM STEEL	0	3.7E-3	5.17E-4	23.8	3.21E-9	1.54E-4	4.4

- The production of leaf spring plays a powerful role in the current generation of LCV and heavy vehicle design. These materials are known to be one of the safest and most shock-absorbing materials available. In light of this, our paper proposes that the Leaf-spring be developed in order to improve all aspects of the Thermo-Mechanical property.
- In this paper, the use of various materials has been considered for production, and the leaf-spring has been analyses in ANSYS with various factors such as equal stress, total deformation, strain, and other variables in

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order to improve the consistency of the leaf-spring.

- Chromium vanadium steel came in second with an excellent result in 'Leaf-Spring.' The deformation factor analysis is thought to have the least effect in leaf spring. The Chromium Leaf spring has ultimate strength, stress, and load resistance, according to this study. In comparison to other leaf spring materials tested, the Chromium vanadium leaf spring endurance limit is extremely high.

Conclusion

The steel combination leaf spring and steel leaf spring were designed and underlying investigation was done. There was a correlation between the combination leaf spring and the steel leaf spring of a similar plan and burden bearing limit. For the steel leaf spring and alloy leaf spring, the stress and displacements were measured using ANSYS. The analysis findings indicates there is andisplacement which is maximum of 3.4e-3 mm and the corresponding displacements in the leaf spring are 3.27e-3 mm, 1.27 mm, 3.44e-3 mm and 3.7e-3 mm respectively in cr-v steel, Ni-cr-mo, Sic-mn and W-cr. From the results of the static analysis, the von-mises stress was also shown to be 5.49e-4 MPa in the steel leaf spring and 23.79 MPa, 23.83 MPa, 23.83 MPa and 23.8 MPa in cr-v steel, Ni-cr-mo, Sic-mn and W-cr. As compared to current steel leaf springs, all four alloy leaf springs have allowable stresses. The comparative analysis with regard to weight and strength was also done between steel and alloy leaf spring. The best substitute material over steel leaf spring is considered to be Chromium Vanadium steel from the above findings.

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