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Design & Analysis of Mono Composite Leaf Spring for Four Wheeler Light Weight Vehicles

S.Raghuvaran & Pedamuthevi Vijayanand

[1]M.Tech (Machine Design) Student, Department of Mechanical Engineering, Holy Mary Institute of Technology and Science, Hyderabad

[2]Associate Professor, Department of Mechanical Engineering, Holy Mary Institute of Technology and Science, Hyderabad

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ABSTRACT

The suspension system is used to isolate the chassis from the shock loads due to Irregularities of the road surface. This must be handled without impairing the stability, Steering or general handling of the vehicle. Suspension system for the cab is placed between the chassis using bolts. The loads coming from the floor and the chassis are taken by the suspension.

The model is designed in Creo and translated to Ansys 16.0. The model is simplified in Ansys by using the preprocessor. Constraint equations and couples are used to connect various regions of the suspension system. The loads are applied on the top flange of the suspension system.

Static analysis is made to study the deflection of the suspension system. Modal analysis is made to check the natural frequencies. Harmonic analysis is also done to plot various graphs between frequency and amplitude.

Results and discussions are made from the results obtained from the Ansys and conclusions are given and scope for future work is also given.

INTRODUCTION

The complete suspension system is to isolate the vehicle body from road shocks and vibrations which would otherwise be transferred to the passengers and load. It must also keep the tires in contact with the road, regardless of road surface. A basic suspension system consists of springs, axles, shock absorbers, arms, rods, and ball joints. The spring is the flexible component of the suspension. Basic types are leaf springs, coil springs, and torsion bars.

Modern passenger vehicles usually use light coil springs. Light commercial vehicles have heavier springs than passenger vehicles, and can have coil springs at the front and leaf springs at the rear. Heavy commercial vehicles usually use leaf springs, or air suspension.

Solid, or beam, axles connect the wheels on each side of the vehicle. This means the movement of a wheel on one side of the vehicle is transferred to the wheel on the other side. With independent suspension, the wheels can move independently of each other, which reduce body movement. This prevents the other wheel being affected by movement of the wheel on the opposite side, and this reduces body movement.

1.1 Principle of suspension SYSTEM

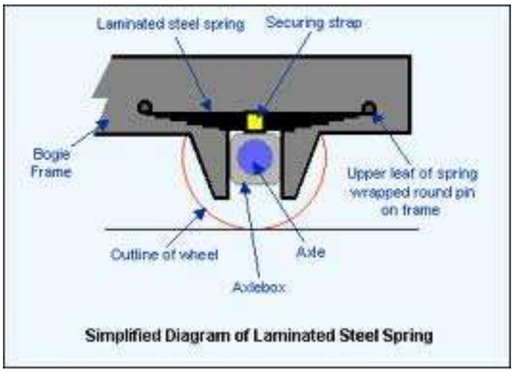

Figure 1: Principle of suspension system

LITERATURE REVIEW

A vast and extensive study of composite materials subjected to properties has been undertaken over many years. The objectives vary from examining the behavior of composite structures under various loads caused by various objects such as leaf spring, mechanical parts in automobiles and other components designed for various purposes for the intention of weight reduction are reviewed. The structures of interest in many applications are commonly composed of E-glass, Carbon, Kevlar, carbon/graphite, Kevlar and glass fiber reinforced polymer matrix composites.

Many studies have focussed the effect of properties of fiber reinforced plastic laminates and components. An extensive literature survey has been carried out and the salient observations are grouped here.

SushilB. Chopade, et al, [1] this paper Study to reduce the weight of product while upholding its strength. To solve the problem using E-glass/Epoxy composite materials. And finally reached to the conclusion of the study that shows the comparative weight reduction of E- glass/ Epoxy composite material between 30-40%. Also, the stresses produced in composite material are also less as compare to conventional steel material.

METHODOLOGY

The vehicles must have a good suspension system that can deliver a good ride and good human comfortsuspension system separate the axle from the vehicle chassis, so that any road irregularities are not transmitted directly to the driver and the load on the vehicle. This is not only allows a more comfortable ride, and protection of the load from possible damage, but it also helps to prevent distortion and damage to the chassis frame.

2D sketching and 3D Modeling of Leaf Spring

The 3D Modeling is a geometrical representation of a real object without losing information which the real object has. Various mechanical design and manufacturing operations modeled using Creo. This software allows the user to make changes very easily without having to go to back at the beginning and update all the drawings and assemblies. Generally Creo is easy to use and feature based parametric solid modeling software with many extended design and manufacturing applications.

In this specific research, based on the dimension obtained from theoretical calculation and direct measuring data 3D modeling and 2D sketching of the leaf spring was created with the help of Creo solid modeling software and analysis is done by using ANSYS 16 workbench for stress and deflection.

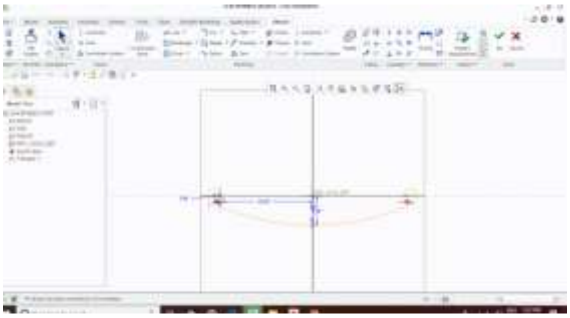

Figure 2: 2D sketch of mono leaf spring

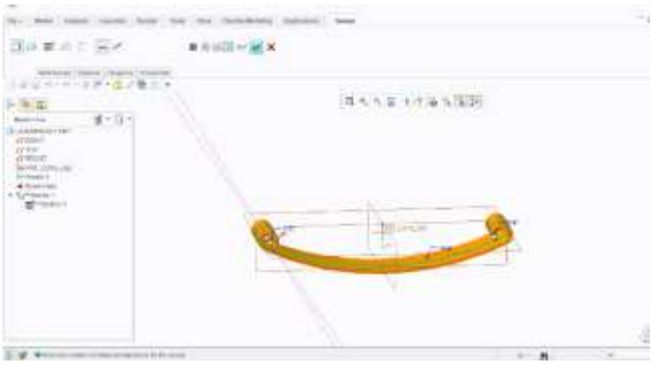

Figure 3:3D modeling of mono leaf spring

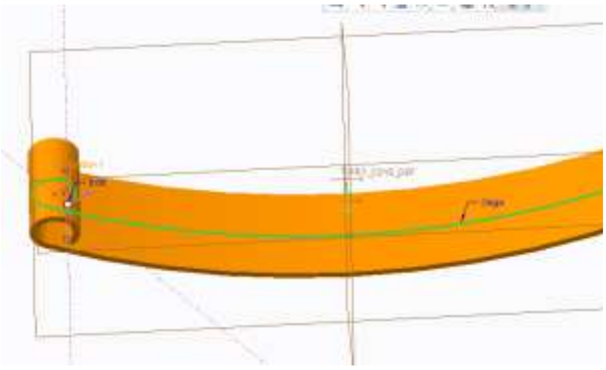

Figure 4: 3D modeling of mono leaf spring

Figure 5: mono leaf spring Isometric view

3.3 Weight Calculations

From the mass, density and volume relation the weight of the leaf spring can be calculated as: Density = $mass/\ volume$

$\rho = M/V$

$M = \rho \times V$

$W = M \times g, where: M = \rho \times V$

Therefore, $W = \rho \times V \times g$

Density of structural steel = 7.85 gm/cm3 and

Take acceleration due to gravity (g) = 10 m/s2

Now weight of the master leaf (W1) = ρ× $V1 \times g$

V1 = $L1 \times t \times w$

RESULTS AND DISCUSSION

4.1 Results of Cast iron Mono Leaf spring

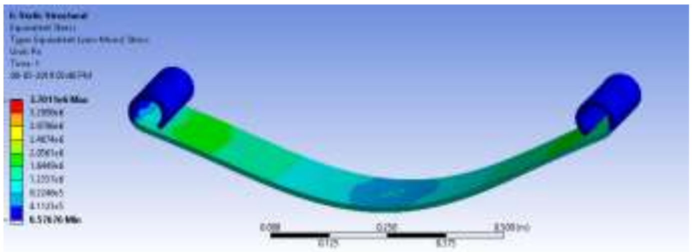

Figure 6:Von misses stress

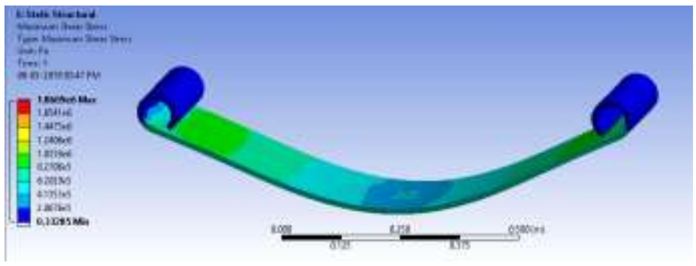

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Figure 7:shear stress

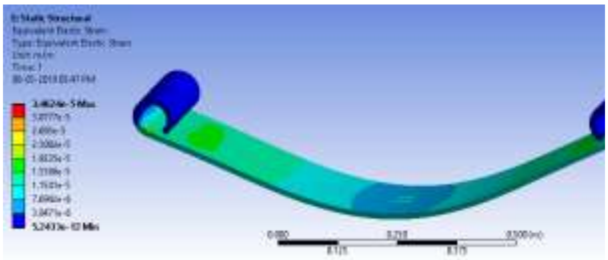

Figure 8: elastic strain

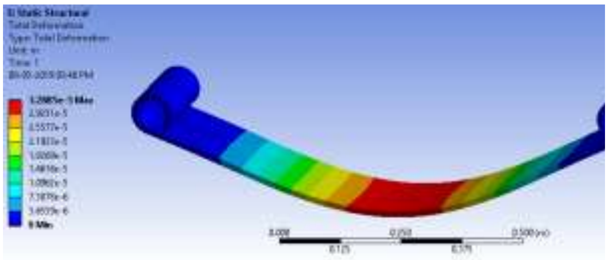

Figure 9:total deformation

Bounding Box	
Properties	
Volume	3.3459e-003 m³
Mass	24.091 kg
Centroid X	6.109e-010 m
Centroid Y	-8.036e-002 m
Centroid Z	5.7264e-018 m
Moment of Inertia Ip1	0.15691 kg·m²
Moment of Inertia Ip2	3.3942 kg·m²
Moment of Inertia Ip3	3.4244 kg·m²
Statistics	

Figure 10: Mass properties

4.2 Results of Steel Mono Leaf spring

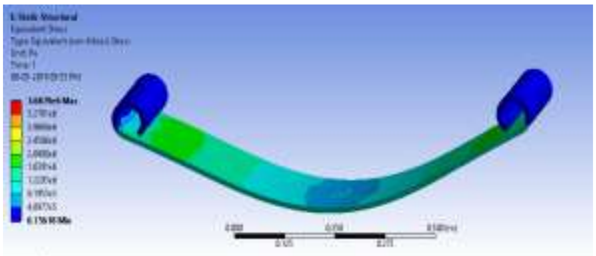

Figure 11:Von misses stress

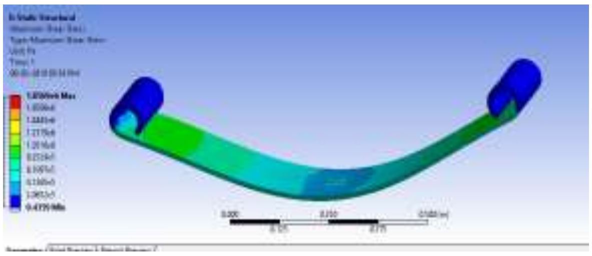

Figure 12:shear stress

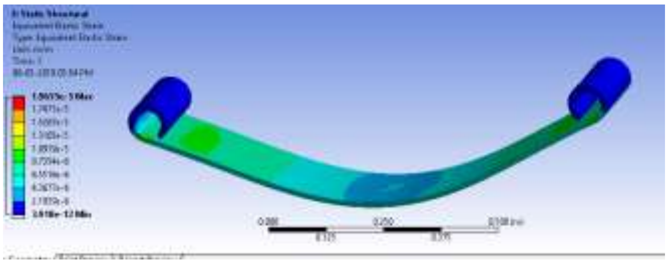

Figure 13: elastic strain

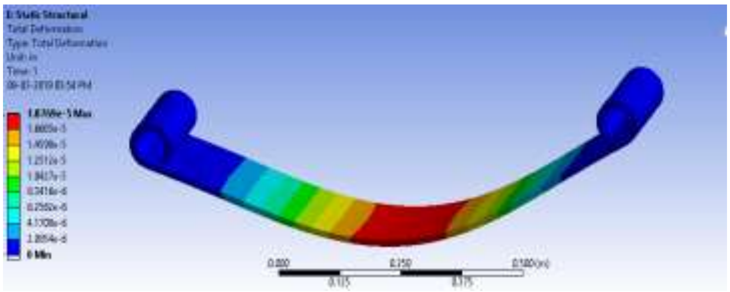

Figure 14: total deformation

Details of " MSBR"

Thermal Strain Effects	Yes
Bounding Box	
Properties	
Volume	3.3459e-003 m³
Mass	25.931 kg
Centroid X	6.109e-010 m
Centroid Y	-8.036e-002 m
Centroid Z	5.7264e-018 m
Moment of Inertia Ip1	0.1689 kg·m²
Moment of Inertia Ip2	3.6535 kg·m²
Moment of Inertia Ip3	3.6859 kg·m²
Statistics	

Figure 15: Mass properties

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4.3 Results of Carbon/epoxy composite Mono Leaf spring

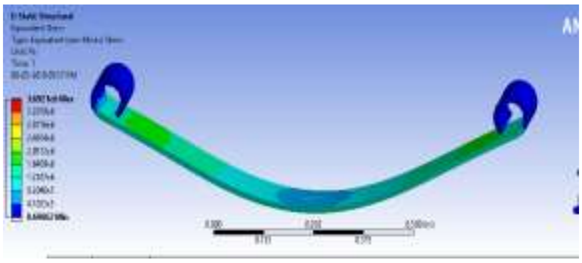


Figure 16:Von misses stress

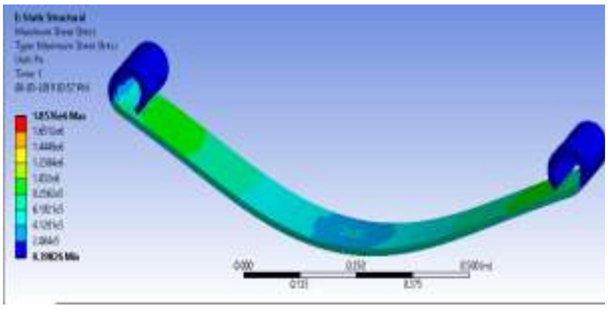
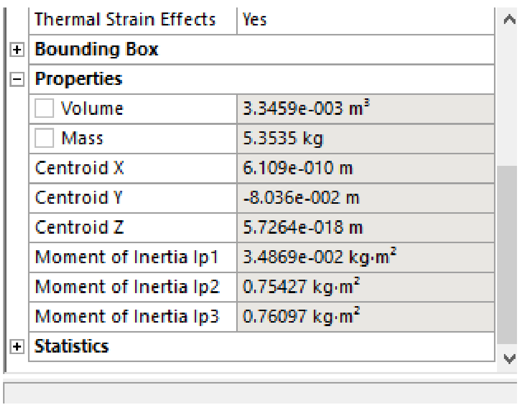


Figure 17:shear stress



Thermal Strain Effects	Yes
Bounding Box	
Properties	
Volume	3.3459e-003 m³
Mass	5.3535 kg
Centroid X	6.109e-010 m
Centroid Y	-8.036e-002 m
Centroid Z	5.7264e-018 m
Moment of Inertia Ip1	3.4869e-002 kg·m²
Moment of Inertia Ip2	0.75427 kg·m²
Moment of Inertia Ip3	0.76097 kg·m²
Statistics	

Figure 18: Mass properties

4.4 Comparison Results

Material	Von-misses stress (MPa)	Shear stress (MPa)	Weight (Kg)
Cast iron	3.7011	1.8609	24.091
Steel	3.6879	1.8569	25.931
Carbon/epoxy	3.6892	1.8573	5.3535

Table 1: overview results

Comparison plots

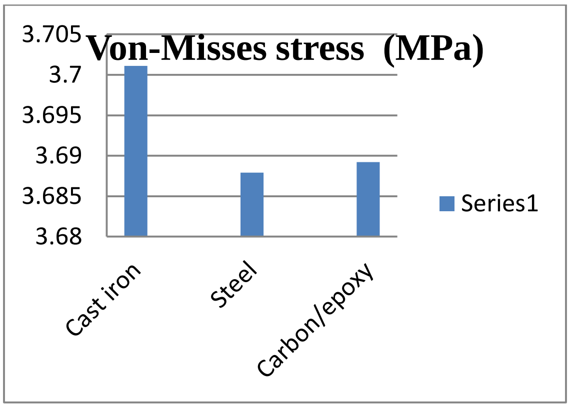
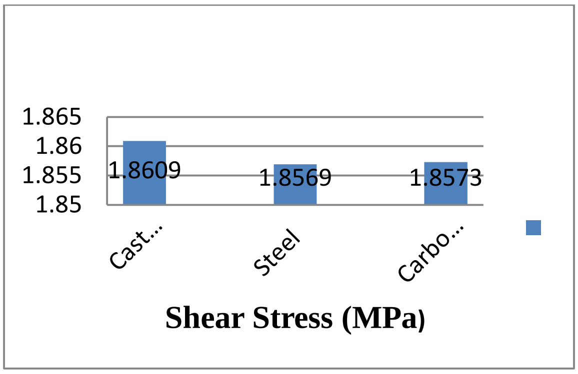


Figure 19: Comparison plot for Von-Misses stress



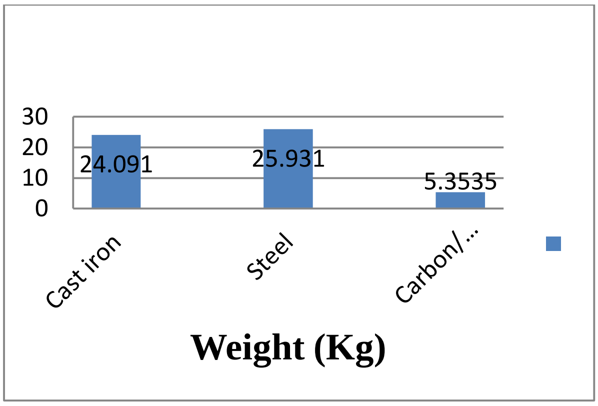


Figure 20: Comparison plot for Weight

From the above table comparing three materials steel and carbon epoxy materials are best suitable for mono leaf spring than the cast iron material. The steel and carbon epoxy material have almost same Von-misses stress and shear stress but when compare to the weight carbon epoxy almost 80% of weight is reduced. From the overall result for mono leaf spring the light weight carbon epoxy material is preferred.

Conclusion

As reducing weight and increasing strength of products are high research demands in the world, composite materials are getting to be up to the mark of satisfying these demands. In this project reducing weight of vehicles by 68.14% and increasing the strength of their spare parts is considered. A mono composite leaf spring for the vehicular suspension system was designed using E-Glass/Epoxy with the objective of minimizing weight of the leaf spring. And it is shown that the resulting design stresses are much below the strength properties of the material satisfying the maximum stress failure criterion. The deflection of the leaf spring along its transverse direction, which is very small compared to the considered maximum deflection.. This particular design is made specifically for the case study/Mahindra/light weight vehicles.

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