

Design and Manufacturing of Leaf and Coil Suspension

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Abstract: The suspension system of an automobile separates the wheel/axle assembly from the body. The primary function of the suspension system is to isolate the vehicle structure from shocks and vibration due to irregularities of the road surface and to maintain contact with the surface thereby providing traction and control. Leaf spring is the preferred type of suspension system in almost all light and heavy commercial and transport vehicles. Leaf spring used in many vehicles due to having some main characteristics which are economical construction, uniformly distributed load, simple assembly in the vehicle and forgiving on use in rough terrain. In this paper we would like to take a look on the leaf spring, its design parameters and analysis. The paper is based on material selection, designing, experimental testing and load analysis etc.

Keywords: ANSYS, Compositions, Experiments, Leaf spring, Material, Mathematics.

1. Introduction

A leaf spring is one of the earliest form of spring and it is commonly used for the suspension in vehicles. Although you may not ever have heard about or even noticed leaf springs on larger tow vehicles, the technology has been around for centuries and is one of the earliest forms of suspension. Even Leonardo da Vinci used leaf springs in his diagram for a self-propelled car. Leaf spring is traditionally made using spring steel but advances in material sciences have enabled the use of composite materials in customized use case scenarios. Although Composite materials offer significant reduction in weight they are highly specialized and require expertise in manufacturing. The composite materials used like Fiber Glass/Epoxy, Carbon fibers/Epoxy etc. The main classification of leaf spring are as follows, Elliptical, Semi Elliptical, Three quarter Elliptical, Quarter Elliptical, and TerraServer's. The leaf spring consists of parts like master leaf, center bolt, central 'U' clamp, Eye. The suspension system also offers directional stability. This implies that the vehicle should have tendency to return to its straight ahead position after turning and it should provide pure rolling motion to wheel.

2. How Leaf Spring Work

Leaf springs are long bundles of spring material that flex under pressure from the movement of a vehicle's axle. The ends

of the leaf spring bundle are attached to the chassis of the car or truck, and the axle is then attached to the center of the leaves. When the axle moves on various road conditions, the leaves compress and absorb the motion rather than transferring all the energy directly to the chassis.

If there's too much weight weighing down for a softly sprung suspension, causing everything to rock and sway, the issue may be rectified by increasing spring stiffness. If a Design and Analysis of Leaf Spring by Using Composite Material for Light Vehicles truck's suspension is too rigid, its wheels will often leave the pavement after hitting bumps; a good suspension, on the other hand, keeps the wheels on the ground as much as possible. Many vehicles use leaf springs to stabilize their towed load and to keep their cargo grounded.

3. Shock Absorber

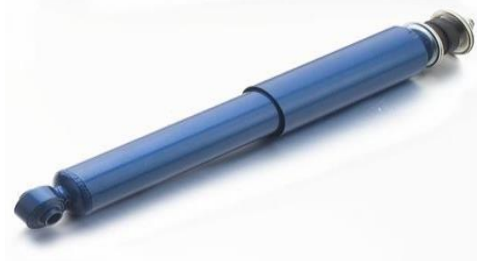


Fig. 1. A shock absorber

A shock absorber is a mechanical or hydraulic device designed to absorb and damp shock impulses, this by converting the kinetic energy of the shock is transferred into another form of energy which is usually heat energy and is then dissipated. Shock absorbers reduce the sudden jerks when traveling over rough ground, leading to improved ride quality and vehicle handling

4. Comparison between Leaf Springs and Coils?

A leaf spring suspension is made of long strip or a series of strips of steel attached at both ends to the frame and suspending the axle in the middle. The side profile of the leaf spring is that of a half ellipse and rectangular cross-sectional view. Coil springs as the name suggests, resembles a helix in appearance. It is situated between the axle and the lower control arm and the

chassis. A coil is a mechanical device which is typically used to store energy and subsequently release it, to absorb shock, or to maintain an attractive or repulsive force between contacting surfaces.

5. Coil Suspension

A coil spring suspension offer wider range of suspension movement and offers the user a wider performance envelope through the suspension range than leaf springs. Almost all high performance vehicles use coil springs wherever possible as budget is usually not a constraint in high performance and competitive environments.



Fig. 2. Coil spring assembly

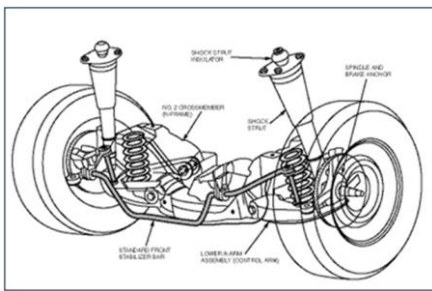


Fig. 3. Coil spring schematic diagram

6. Leaf Spring Calculation

- Total load $2P = 20000N$
- Number of leafs $n=4$
- Young's modulus $E=2.1 \cdot 10^5$
- Yield strength = $850N/mm^2$
- Total length of the leaf $2l=1000mm$
- Half length of the leaf $l=500mm$
- $P=20000/(4 \cdot 2)$
- $\sigma b = 12pl/6t^2(3n_e + 2n_g)$
- $850=12 \cdot 2500 \cdot 2500/50 \cdot t^2(3(1)+2(3))$
- $t^2=12 \cdot 2500 \cdot 500/50 \cdot 580 \cdot 9$
- $t=6.26mm$

- $Y=12pl^3/bt^3(3n_e+2n_g) \cdot E$
- $Y=12 \cdot 2500 \cdot (500)^3/(50 \cdot (6.26)^3((3(1)+2(3)) \cdot 2.1 \cdot 10^5))$
- $Y=162.33mm$
- Camber radius $=0.5 \cdot y$
 $=0.5 \cdot 162.33$
 $=81.175mm$
- Radius of curvature
 $R=l^2/2 \cdot Y$
 $=500^2/2 \cdot 162.33$
 $R=770.03mm$

7. Coil Suspension Calculation

- Wire diameter (d): 12 mm
- Mean diameter of spring (D): 75 mm
- Outer diameter of spring (do): 87 mm
- Free length of spring (l): 210 mm
- No of active coils (i): 6
- Pitch (p): 30 mm

Table 1
Quick comparison of leaf springs and others

	Leaf Suspension	Mepherson Strut	Double Wishbone	Trailing Arm
Space	Occupies no space as the whole system remains under the frame of the car	Intrusive but less than Double wishbone.	Occupies lots of space	Requires less space
Maintenance	Requires least maintenance	Requires highest maintenance	High maintenance setup	Requires low maintenance.
Design Complexity	Simple design	Relatively high complex design.	Highest complexity design	Simpler design compared to McPherson strut and double wishbone
Vehicle Stability	Offers optimum balance between ride and stability	Good for vehicle stability	Best for vehicle stability	Bad for vehicle stability
Manufacturing Complexity	Easy manufacturing process	Complex to manufacture and to assemble	Easy to manufacture	Easier to manufacture
Manufacturing Cost	Least expensive	Costlier	Costliest	Less expensive
Load Bearing	Can be used for heavy loads	Can be used only for calculated loads	Can be used only for calculated loads	Also used for heavier loads
Serviceability	Requires simple tools and procedures	Requires complex procedures to service the system	Most complex to service and to maintain in working condition	Simple system to maintenance
Constraints	Low number of constraints	High number of constraints	Highest number of constraints	Moderate number of constraints
Failure Redressal	Vehicle can be driven in unladed condition after failure	Failure is debilitating and vehicle can't be driven any longer.	Vehicle can't be driven after failure.	Requires immediate rectification.

- Spring index (c) 6.25
- Stress factor (K) 1.24
- Max shear stress (τ_{max}) 342.5 Mpa
- Max deflection (γ_{max}) 28.5 mm 32.5 mm
- Spring stiffness (k) 90.90 N/mm 76.92 N/mm spring (F): 2500 N

8. Design Report

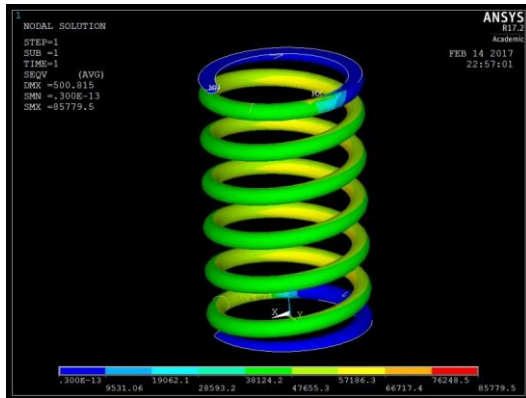


Fig. 4. Coil spring analysis

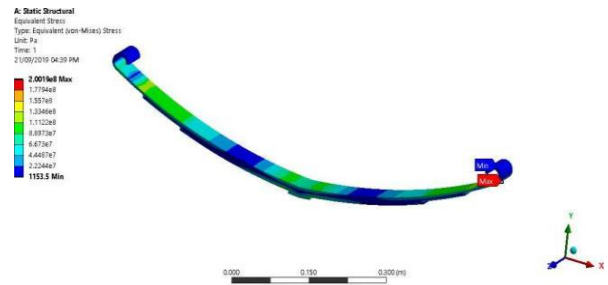


Fig. 5. Leaf spring FEA analysis

9. Conclusion

This paper presented design and manufacturing of leaf and coil suspension.

References

- [1] Design data book, P. S. G. Tech.
- [2] R. S. Kurmi, "Design of machine elements."