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Modelling and Analysis of Suspension System

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ABSTRACT:

A shock absorber is a mechanical device designed to smooth out or damp shock impulse,and convert kinetic energy to another form of energy. It is a type of dashpot. In a vehicle, shock absorbers reduce the effect of traveling over rough ground, leading to improved ride quality and vehicle handling. While shock absorbers serve the purpose of limiting excessive suspension movement, their intended sole purpose is to damp spring oscillations. Shock absorbers use valving of oil and gasses to absorb excess energy from the springs. Spring rates are chosen by the manufacturer based on the weight of the vehicle, loaded and unloaded. Some people use shocks to modify spring rates but this is not the correct use. Along with hysteresis in the tire itself, they damp the energy stored in the motion of the unsprung weight up and down. Effective wheel bounce damping may require tuning shocks to an optimal resistance. Spring-based shock absorbers commonly use coil springs or leaf springs, though torsion bars are used in tensional shocks as well.

Ideal springs alone, however, are not shock absorbers, as springs only store and do not dissipate or absorb energy. Vehicles typically employ both hydraulic shock absorbers and springs or torsion bars. In this combination, "shock absorber" refers specifically to the hydraulic piston that absorbs and dissipates vibration. CATIA is a tool based software used to model 3D structures, automobile, manufacturing components. By using this software complete model is designed. In this project we model/design the SUSPENSION SYSTEM, the parts of the complete model is modeled and assembled together which obtains a complete shock absorber. Drafting of the assembly is done. Here the geometrical views of the component are projected. And then finally do the analysis of the suspension system with adding material.

Introduction

Suspension is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels and allows relative motion between the two.[1] Suspension systems serve a dual purpose — contributing to the vehicle's road holding/handling and braking for good active safety and driving pleasure, and keeping vehicle occupants comfortable and reasonably well isolated from road noise, bumps, and vibrations, etc. These goals are generally at odds, so the tuning of suspensions involves finding the right compromise. It is important for the suspension to keep the road wheel in contact with the road surface as much as possible, because all the forces acting on the vehicle do so through the contact patches of the tires.

The suspension also protects the vehicle itself and any cargo or luggage from damage and wear. The design of front and rear suspension of a car may be different. Leaf springs have been around since the early Egyptians. Ancient military engineers used leaf springs in the form of bows to power their siege engines, with little success at first. The use of leaf springs in catapults was later refined and made to work years later. Springs were not only made of metal, a sturdy tree branch could be used as a spring, such as with a bow.

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By the early 19th century, most British horse carriages were equipped with springs; wooden springs in the case of light one-horse vehicles to avoid taxation, and steel springs in larger vehicles. These were made of low-carbon steel and usually took the form of multiple layer leaf springs.[2]The British steel springs were not well suited for use on America's rough roads of the time, and could even cause coaches to collapse if cornered too fast. In the 1820s, the Abbot Downing Company of Concord, New Hampshire re-discovered the antique system whereby the bodies of stagecoaches were supported on leather straps called "thoroughbraces", which gave a swinging motion instead of the jolting up and down of a spring suspension (the stagecoach itself was sometimes called a "thoroughbrace").

Automobiles were initially developed as self-propelled versions of horse drawn vehicles. However, horse drawn vehicles had been designed for relatively slow speeds and their suspension was not well suited to the higher speeds permitted by the internal combustion engine. In 1901 Mors of Paris first fitted an automobile with shock absorbers. With the advantage of a dampened suspension system on his 'Mors Machine', Henri Fournier won the prestigious Paris-to-Berlin race on the 20th of June 1901. Fournier's superior time was 11 hrs 46 min 10 sec, while the best competitor was Léonce Girardot in a Panhard with a time of 12 hrs 15 min 40 sec.[3]

In 1920, Leyland Motors used torsion bars in a suspension system. In 1922, independent front suspension was pioneered on the Lancia Lambda and became more common in mass market cars from 1932.[

Spring rate:

The spring rate (or suspension rate) is a component in setting the vehicle's ride height or its location in the suspension stroke. When a spring is compressed or stretched, the force it exerts is proportional to its change in length. The *spring rate* or *spring constant* of a spring is the change in the force it exerts, divided by the change in deflection of the spring. Vehicles which carry heavy loads will often have heavier springs to compensate for the additional weight that would otherwise collapse a vehicle to the bottom of its travel (stroke). Heavier springs are also used in performance applications where the loading conditions experienced are more extreme.Springs that are too hard or too soft cause the suspension to become ineffective because they fail to properly isolate the vehicle from the road. Vehicles that commonly experience suspension loads heavier than normal have heavy or hard springs with a spring rate close to the upper limit for that vehicle's weight.

This allows the vehicle to perform properly under a heavy load when control is limited by the inertia of the load. Riding in an empty truck used for carrying loads can be uncomfortable for passengers because of its high spring rate relative to the weight of the vehicle. A race car would also be described as having heavy springs and would also be uncomfortably bumpy. However, even though we say they both have heavy springs, the actual spring rates for a 2,000 lb (910 kg) race car and a 10,000 lb (4,500 kg) truck are very different. A luxury car, taxi, or passenger bus would be described as having soft springs. Vehicles with worn out or damaged springs ride lower to the ground which reduces the overall amount of compression available to the suspension and increases the amount of body lean.

Performance vehicles can sometimes have spring rate requirements other than vehicle weight and load.

[Edit] Mathematics of the spring rate:

Spring rate is a ratio used to measure how resistant a spring is to being compressed or expanded during the spring's deflection. The magnitude of the spring force increases as deflection increases according to Hooke's Law. Briefly, this can be stated as

$$F = -kx$$

Where

> F is the force the spring exerts
> k is the spring rate of the spring.
> x is the displacement from equilibrium length i.e. the length at which the spring is neither compressed or stretched.

Spring rate is confined to a narrow interval by the weight of the vehicle, load the vehicle will carry, and to a lesser extent by suspension geometry and performance desires. Spring rates typically have units of N/mm (or lbf/in). An example of a linear spring rate is 500 lbf/in. For every inch the spring is compressed, it exerts 500 lbf. A non-linear spring rate is one for which the relation between the spring's compression and the force exerted cannot be fitted adequately to a linear model. For example, the first inch exerts 500 lbf force, the second inch exerts an additional 550 lbf (for a total of 1050 lbf), the third inch exerts another 600 lbf (for a total of 1650 lbf). In contrast a 500 lbf/in linear spring compressed to 3 inches will only exert 1500 lbf. The spring rate of a coil spring may be calculated by a simple algebraic equation or it may be measured in a spring testing machine. The spring constant k can be calculated as follows:

$$k = \frac{d^4 G}{8 N D^3}$$

where d is the wire diameter, G is the spring's shear modulus (e.g., about 12,000,000 lbf/in² or 80 GPa for steel), and N is the number of wraps and D is the diameter of the coil.

Wheel rate:

Wheel rate is the effective spring rate when measured at the wheel. This is as opposed to simply measuring the spring rate alone. Wheel rate is usually equal to or considerably less than the spring rate. Commonly, springs are mounted on control arms, swing arms or some other pivoting suspension member. Consider the example above where the spring rate was calculated to be 500 lbs/inch, if you were to move the wheel 1 in (2.5 cm) (without moving the car), the spring more than likely compresses a smaller amount. Lets assume the spring moved 0.75 in (19 mm), the lever arm ratio would be 0.75:1. The wheel rate is calculated by taking the square of the ratio (0.5625) times the spring rate. Squaring the ratio is because the ratio has two effects on the wheel rate. The ratio applies to both the force and distance traveled.

Wheel rate on independent suspension is fairly straightforward. However, special consideration must be taken with some non-independent suspension designs. Take the case of the straight axle. When viewed from the front or rear, the wheel rate can be measured by the means above. Yet because the wheels are not independent, when viewed from the side under acceleration or braking the pivot point is at infinity (because both wheels have moved) and the spring is directly in line with the wheel contact patch. The result is often that the effective wheel rate under cornering is different from what it is under acceleration and braking. This variation in wheel rate may be minimized by locating the spring as close to the wheel as possible. Wheel rates are usually summed and compared with the sprung mass of a vehicle to create a "ride rate" and corresponding suspension natural frequency in ride (also referred to as "heave").

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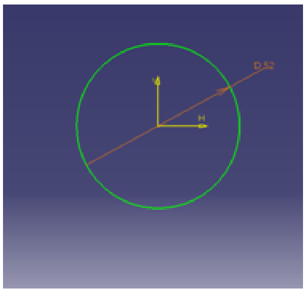
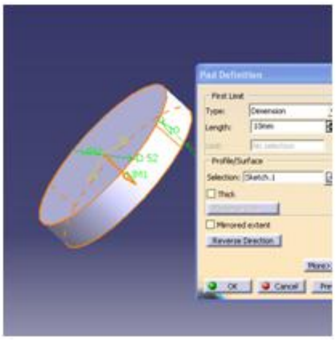
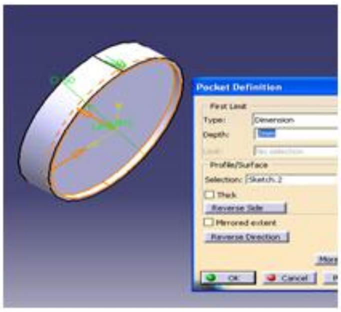
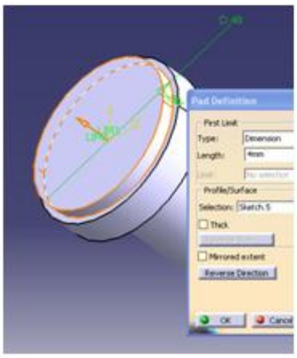
This can be useful in creating a metric for suspension stiffness and travel requirements for a vehicle.

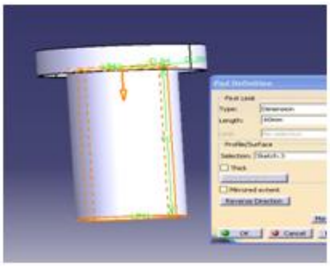
Sketcher of suspension

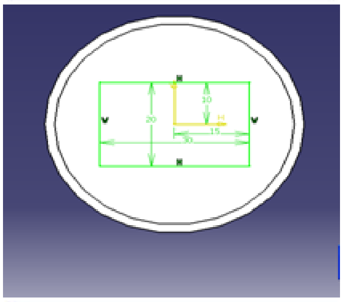


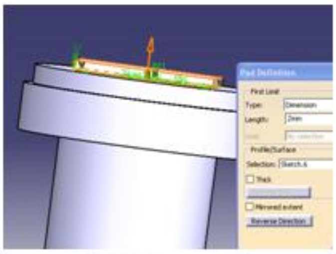


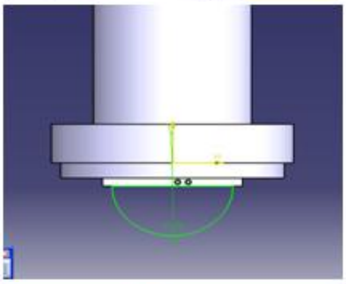


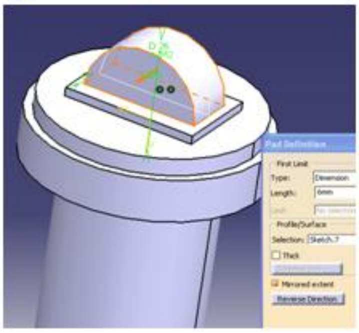












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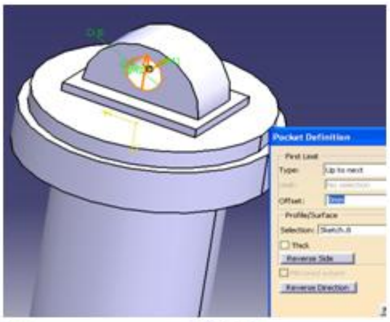
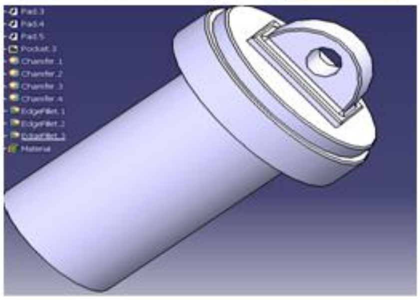
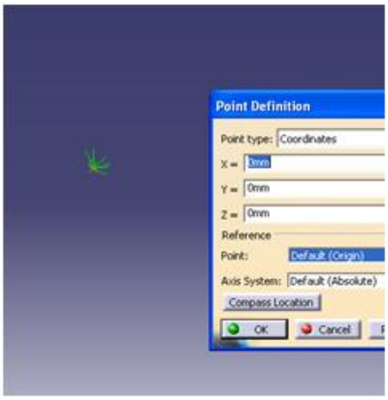
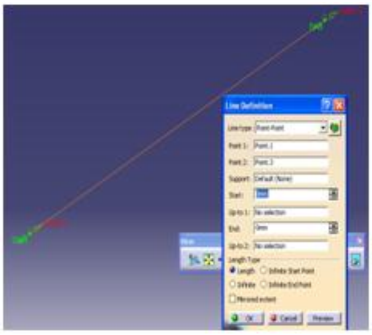


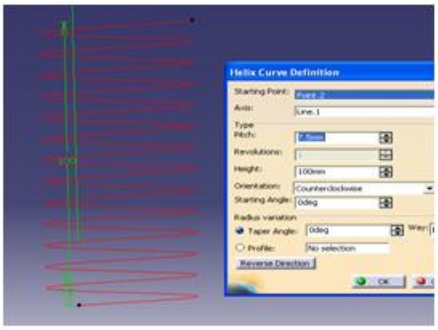


Sketcher of helical spring

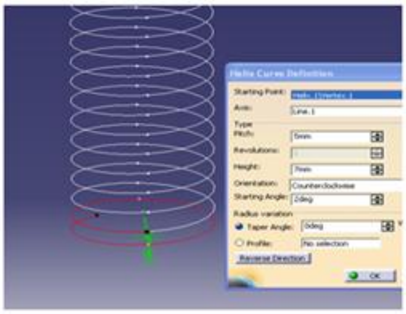




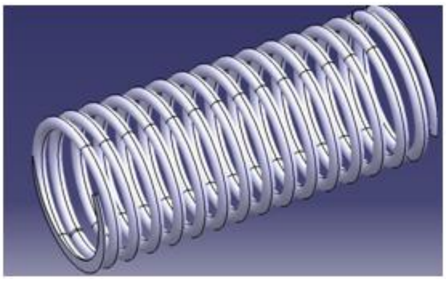
Helix 1



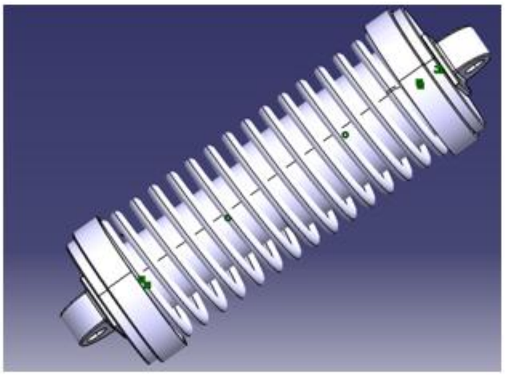
Helix2



Helix 3



Assembly of suspension system



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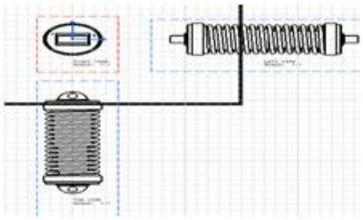


- **Material Data**
  - Structural Steel
  -

FIGURE 3
Model (A4) > Static Structural (A5) > Solution (A6) > Total Deformation > Figure

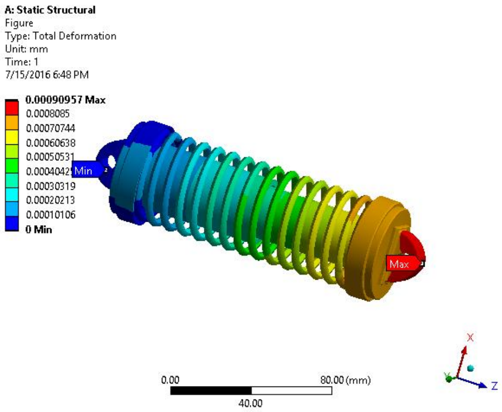


FIGURE 5
Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Stress > Figure

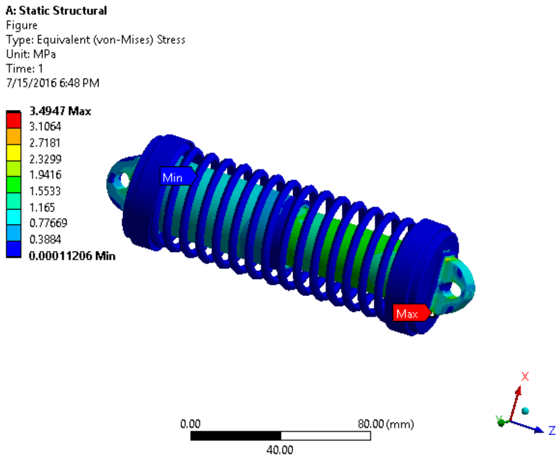
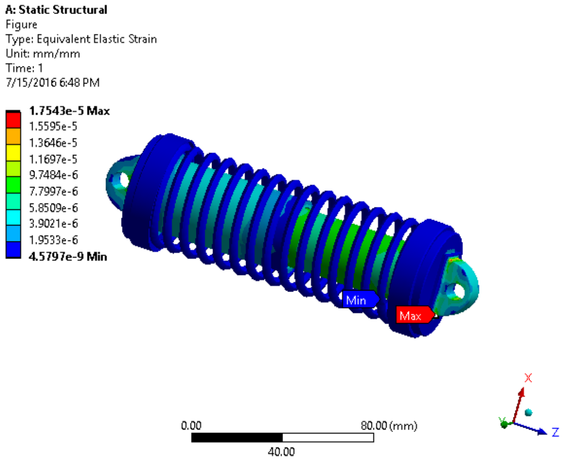


FIGURE 7
Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Elastic Strain > Figure



CONCLUSION:

The present work is optimum design and analysis of a suspension spring for motor vehicle subjected to static analysis of helical spriing the work shows the strain and strain response of spring behavior will be observed under prescribed or expected loads and the induced stress and strains values for structural steel is less compared to chrome vanadium material also it enhances the cyclic fatigue of helical spring. Based on the modeling and analyses conclude that the structural steel material is best suitable for production of helical spring‟s compared to chromo vanadium steel materials which are used in motor vehicles.