Multiphysics CAE of Shock Absorber

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Abstract

Shock absorber is a mechanical device engineered to damp shock impulses and dissipates kinetic energy. In Vehicle it reduces the effects of impact loads during travelling over rough grounds, leading to improve ride quality, vehicle handling and provide better comfort. In a vehicle suspension system the spring is critical part, which undergo high deformation and stress due to heavy impact loads during its life cycle. Therefore the design of spring in shock absorber need more attention for improved structural performance. Cylindrical springs with constant major diameter are the widely used in vehicle suspension systems, which comes with limitation in physical performance. Cylindrical springs having constant major diameter and pitch are ineffective to achieve negative solid height, constant spring rate and smooth oscillation. To achieve negative solid height, constant spring rate and smooth oscillation; a feasible spring design is required. This experiment deals with the development of Conical spring to obtain improved performance in a shock absorber. Conical suspension spring shows potential to achieve negative solid height, constant spring rate and smooth oscillation due to it's physical design compared to cylindrical springs. Comparative finite element analysis is performed to validate and distinguish mechanical performance of conical spring from cylindrical compression spring.

Keywords:- Shock absorber, Vehicle suspension system, Suspension spring, Negative solid height.

1.0 Introduction

Shock absorber have become more interest to the automotive manufacturers each years, until they are now considered as an important parts of vehicles. The shock absorber is used to observe the vibrations from shock loads due to irregularities of the road surface. It operates without affecting the stability, steering (or) handling of the vehicle. Generally for light vehicles, cylindrical coil springs are used as suspension elements. The present investigation attempts to analyze performance of a shock absorber with different suspension springs. This investigation includes comparative modeling and analysis of solid height, damping performance, oscillation capabilities of closed coil conical and cylindrical compression springs and suggested the suitable design for improved performance.

1.2 Vehicle suspension system

The suspension system of a ground vehicle is usually designed with objectives; to isolate the vehicle body from road irregularities and to maintain wheel contact with the ground surface. Isolation is achieved by the use of helical compression springs and dampers and by elastic mountings at the connections of the individual suspension components. From practical point of view, there are two major disturbances on a vehicle, named as Road disturbances and Load disturbances. Road disturbances have the characteristics of large magnitude in low frequency such as hills and small magnitude in high frequency such as road roughness. Load disturbances include the variation of loads induced by accelerating, braking and cornering. Therefore, a good suspension design is concerned with disturbance rejection from these disturbances to the outputs. Conventional suspension needs to be "soft" to insulate against road disturbances and "hard" to insulate against load disturbances. Therefore, shock absorber design is an art of compromise between these two goals. The main functions of shock absorbers in a suspension system is to isolate the structure and occupants from shocks and vibrations generated by the uneven road surfaces. The shock absorber requires an elastic resistance to absorb the road shocks and this job is fulfilled by the suspension Springs.

The primary objectives of a vehicle suspension system is

A. To provide good ride and handling performance

- ➔ Vertical compliance providing chassis isolation.
- ➔ Ensures that the wheels follow the road.
- ➔ Ensures minimal tire load fluctuation.

B.To ensure that proper steering is maintained during maneuvering.

- ➔ Wheels to be maintained at proper position with respect to road surface.

C.To ensure that the vehicle responds favorably to control forces produced by the tires during

- ➔ Longitudinal braking.
- ➔ Accelerating forces.
- ➔ Lateral cornering forces.
- ➔ Braking and accelerating torques.

D.To provide isolation from high frequency vibration of tire excitation

- ➔ Requires proper isolation in the suspension joints.
- ➔ Prevent transmission of 'road noise' to the vehicle body.

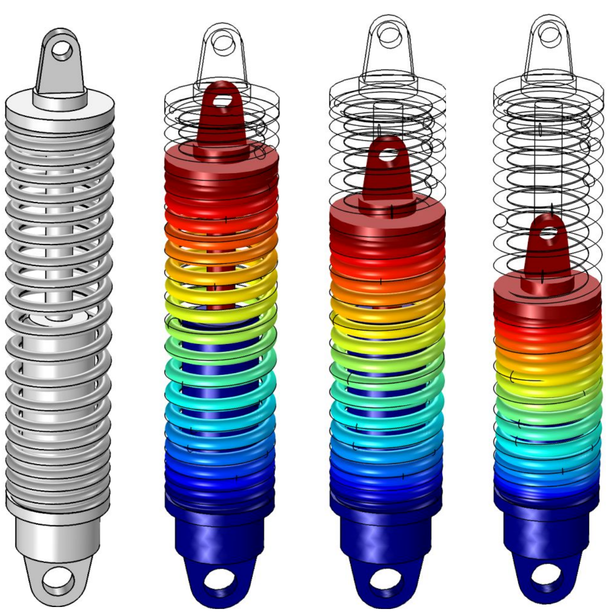

Figure.1 CAE Simulation of Shock Absorber.

1.3 Suspension Springs

Springs are crucial suspension components on automobiles which are necessary to minimize the impacts and bumps due to uneven roads and provides comfortable rides. Spring is defined as an elastic body, whose function is to compress when loaded and regain it's original shape when the load is removed. Mechanical springs are used in shock absorber to exert force, provide flexibility, and to store or absorb energy. The force can be a axial push or pull, or it can be radial. The torque can be used to cause a rotation. Springs can be classified according to the direction and characteristics of the forces exerted by the spring when it is deflected. Without any applied load, the spring's height is called the free length. When a compression force is applied, the coils are pressed together until they all touch each other. After compression the compressed spring height is called the solid length. The main objectives of helical springs are as follows.

- To apply force
- To control motion
- To control vibration
- To reduce impact

1.4 Compression springs

Compression springs are helical coil springs wound with spacing between the coils so that they can be compressed from their free length to a shorter operating length. This allows the spring to store energy and provide a force or pressure. Some uses of compression springs includes:

- Resisting the movement of another component.
- Returning a component to a desired position.
- Providing consistent pressure.
- Storing and releasing energy.

1.5 Cylindrical compression spring

These springs are wound in the form of helix of a wire on cylindrical geometry. The major stresses produced in this are shear due to twisting. The applied load is parallel to the axis of spring. The cross section of the wire may be round, square or rectangular. Figure.2 shows the cylindrical compression spring model used in this experiment. The cylindrical compression spring is rigidly attached with two circular rings at both ends.

Figure.2 Cylindrical compression spring design.

1.6 Conical compression spring

These springs are wound in the form of helix of a wire on conical geometry. The major stresses produced in this are also shear due to twisting, tensile and compressive stress due to bending. Figure.3 shows a conical compression spring design used in this experiment. In this design both ends of the springs are rigidly attached with two different diameter circular rings.

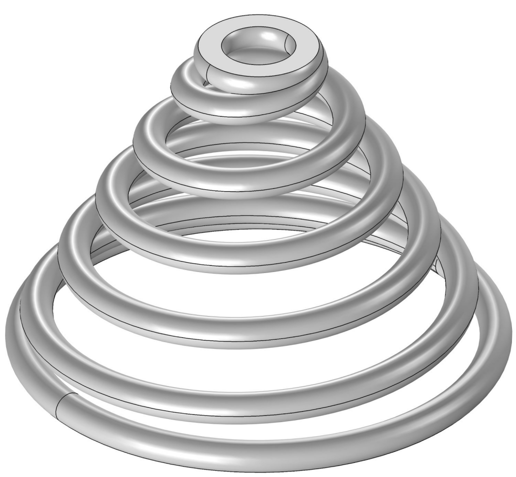

Figure.3 Conical compression spring design.

2.0 Numerical Modeling & simulation

In this investigation, the damping performance of Cylindrical and Conical compression springs are analyzed numerically. The numerical model is developed with solid mechanics interface of COMSOL Multiphysics. A Linear-Stationary analysis is performed to obtain desired deflection and stress at various loading conditions.

2.1 Model Definition

The figure.2 and 3 represents the CAD models of respective spring designs used in this investigation. Both models are designed to have same coil diameter, free length, number of active coils and same material properties.

Material Density (ρ) = 7850 kg/m^3

Young's Modulus (E) = 200 GPa

Poisson's Ratio (ν) = 0.33

Individual spring models are assumed to be fixed at bottom end and compressive force is applied to the top end. The radial deflection is neglected for the current experiments. A varying compressive loads of 100 N to 2000 N is applied parametrically in the linear stationary study environment.

2.2 Governing Equation

The following differential equation is implemented for both spring designs and solved in Solid mechanics physics environment of COMSOL Multiphysics.

$$\frac{d^2x}{dt^2} + \frac{k}{m}x = 0$$

Where x = Displacement

k = Spring Stiffness

m = Loaded Mass

3.0 Result & Discussion

Simulation results shows maximum deflection and von mises stress values in both models for specified load parameters. The Cylindrical spring design shows limited deflection of 45 mm at 700 N [Figure.8], while Conical spring operates at 2000 N with 80 mm deflection [Figure.10]. The Conical spring shows maximum compression, negative solid-height and better oscillations compared to Cylindrical spring.

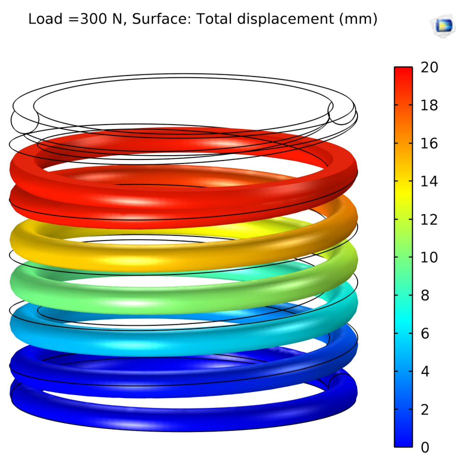

Figure.4 Maximum Deflection at 300 N.

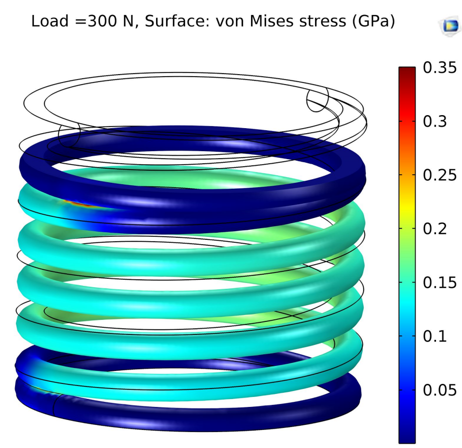

Figure.5 Maximum Stress at 300 N.

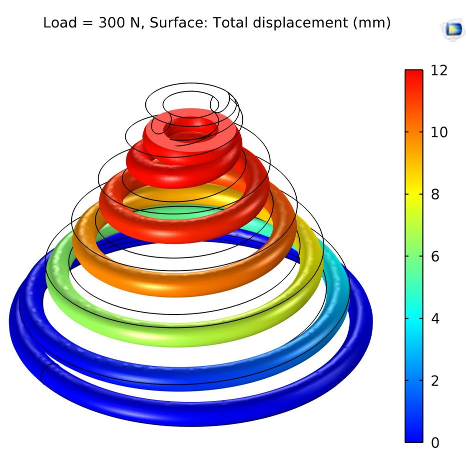

Figure.6 Maximum Deflection at 300 N.

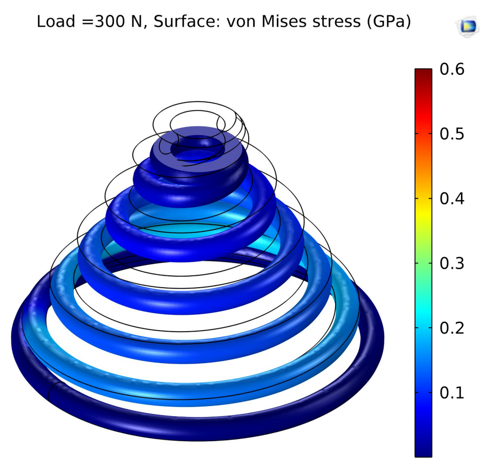

Figure.7 Maximum Stress at 300 N.

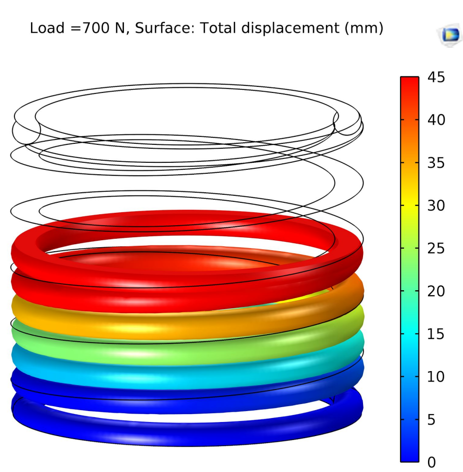

Figure.8 Maximum Deflection at 700 N.

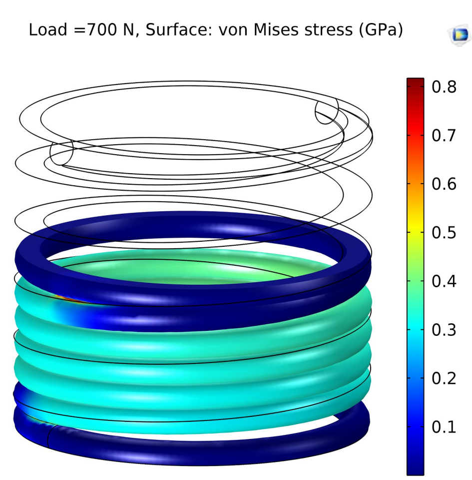

Figure.9 Maximum Stress at 700 N

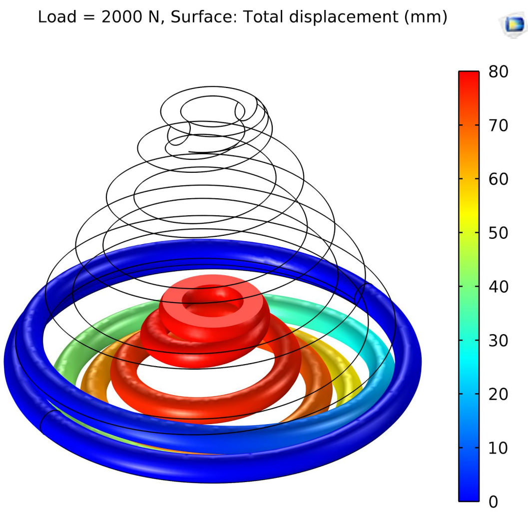

Figure.10 Maximum Deflection at 2000 N.

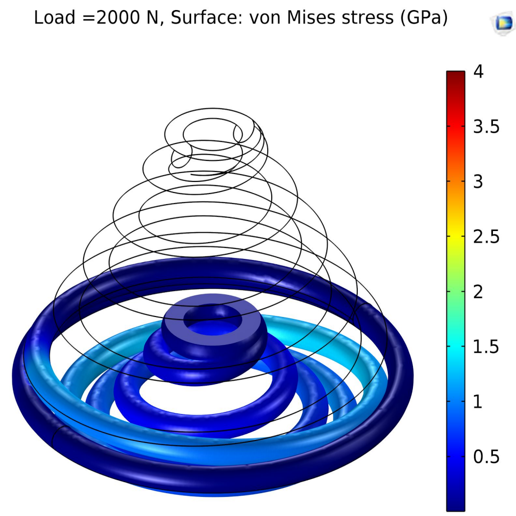

Figure.11 Maximum Stress at 2000 N.

4.0 Conclusions

This optimized Conical spring design shows potential to operate in harsh condition compared to regular springs in a Shock absorber. The Conical compression spring design can offer superior lateral stability and ride comfort. Negative solid height can be achieved by conical compression springs in a Shock Absorber which will help to reduce impacts. The conical spring design can provide better oscillation and wheel to ground contact. Nonlinear multiphysics study will be performed, for structural design optimization and development of energy harvesting, low cost, high performance Shock absorber.

5.0 Acknowledgement

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