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# DESIGN AND ANALYSIS OF HELICAL SPRING IN TWO WHEELER SUSPENSION SYSTEM USING FINITE ELEMENT METHOD

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***Abstract -*** *Automobile suspension plays an important role in passenger comfort and stability of the vehicle. In this research paper helical spring related to the light vehicle suspension systems under the effect of a uniform loading has been studied and a model is created for the existing design of CBZ extreme bike helical coil spring together with modified profiles of helical spring square and square fillet by using modeling software Creo Parametric 2.0*

*This research paper deals with the analysis of dual suspension by using ANSYS Workbench 14.0 simulation software. Using the finite element approach, results are compared on the basis of Static Structure analysis. Further results for various spring profiles are compared.*

***Key Words*: FEA, Shock absorber, ANSYS, Static, Optimization.**

## 1. INTRODUCTION

An automobile chassis is or body mounted on axes, but not directly, but through some form of spring to provide vehicle safety and passenger comfort. The shock absorber is an important part of automotive suspension system which has an effect on ride characteristics such as ride comfort and driving safety. In every moving vehicle there must have a good suspension to absorb the shock of the tires and wheels meeting bumps and holes in the road. The energy of road shock causes the spring to oscillate; this oscillation is restricted to a reasonable level by Shock absorber. The purpose of Shock Absorber (suspension forks, rear shocks) is to dissipate kinetic energy into vertical motion of the body or any motion arises from the rough road. Traditionally automotive suspension designs have been compromised between the three conflicting criteria's namely vehicle handling, load carrying, and passenger comfort.

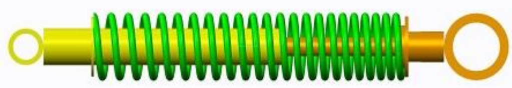


**Fig –1:** Rear shock absorber model

## 2. LITERATURE SURVEY

**Vijayeshwar BV. et al. [1]** In this research paper they evaluated the manufacturing of helical coil suspension springs as per requirement. The objective of this work is a comparative study and analysis of suspension helical coil spring with two different materials like Chrome Silicon and Hard drawn carbon steel. They designed the shock absorber model using Pro/E Creo 2.0 and analysis of stress and deflection they used ANSYS 15.0. After the theoretical and ANSYS results shows that Chrome silicon spring steel is the optimum suitable material with low weight and high stiffness for helical spring applications like mono shock suspensions in bikes and many more.

**N. Sai Kumar and Prof. R. Vijay Prakash [2]** in this research paper they have design and analyze the performance of the shock absorber by varying the wire diameter of the coil spring. They explain all types of shock absorber properties and using metal spring wire. They consider various types of motorbike spring specification and modeling of suspension springs. They used alloy steel. Chrome vanadium steel of spring materials. They determine the analysis of maximum shear stress, maximum principal stress, normal stress, strain, maximum principle strain, normal strain, total deformation are noted. The results of alloy steel are showing the best results in three vehicles (Among there for Yamaha alloy steel got the least stress). The alloy steel is preferable compared to chrome vanadium steel.

**Suraj R. Bhosle et al. [3]** In this research paper the comparative study of suspension helical coil spring with different materials using finite element analysis. They create the shock absorber model in Creo Parametric 2.0 and structural analysis of the same is done using ANSYS 17.0. The comparative study shows the optimum material to be used for the spring by proper analysis of the deflection and stresses of the helical spring. They used four different material of spring are Chrome vanadium, Hard drawn spring wire, steel, Oil tempered carbon steel and Stainless steel. After the analysis the chrome vanadium stands out to be efficient material for spring especially at higher loads.

**MacArthur, L. Stewart [4]** In this paper they determine the maximum torsion stress, fatigue life, natural frequency and load loss due to stress relaxation of helical compression spring. The intent of this paper was to make a useful contribution to the published works for evaluating round wire helical compression springs. They used FEA software to construct a structural model of a helical compression spring to simulate its full range of compression. The aim of these researchers was to replace steel with a viable composite material. In this type of materials resulted in a reduction in stress and weight, but an increase in displacement. They used an innovative methodology for constructing a virtual prototype of a helical compression spring.

**P.R. Jadhav et al. [5]** This paper deals with analysis of dual suspension by using FE approach and validated with analytical with varying speed. In this research helical spring related to the light vehicle suspension system under the effect of a uniform loading has been studied and finite element analysis has been compared with analytical solutions. They compared the analysis results to determine stress and deflection at various speeds for carbon steel material. The model of dual suspension motor vehicle that can vibrate in the vertical direction while traveling over a rough road. The results are elaborated in an earlier chapter the brief discussion and conclusion is present as follows. The deflection is Maximum in between the 3km/hrs to 10km/hrs and further reduces as speed increases stress is Maximum in between the 3km/hrs to 10km/hrs and further reduces as speed increases.

## 3. RESEARCH METHODOLGY

The finite element analysis bolsters many distinctive analysis packages, ANSYS Workbench 14.0 is one those. The 3D modeling is a process of transformation program which creates an ANSYS input record from the geometry portrayal created in Creo Parametric 2.0. After the model creation, the transformation program translates the Creo model into an ANSYS input record i.e. IGES format. The input file can be viewed in either of the software.

Now the converted input file is imported into ANSYS for further processing. After importing the input file, the meshing has taken place by selecting appropriate 3D element size and shape.

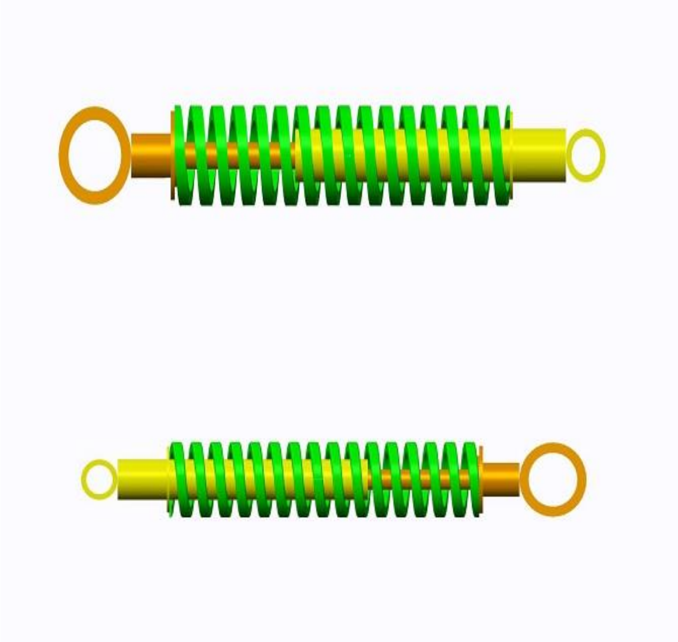
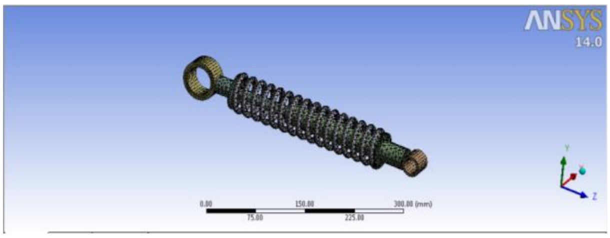
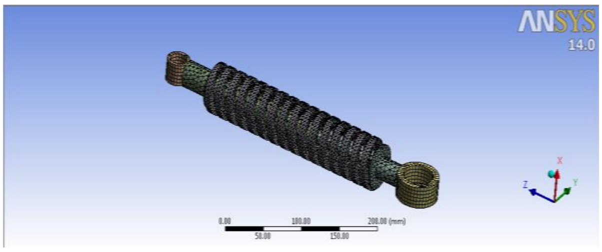


**Fig-2:** Modified model (Square and Square fillet profile of spring) of the shock absorber

### 3.1 Meshing of the model

The geometry has been imported into ANSYS Workbench 14.0. After completing geometry cleanup, 3D solid mesh has been carried out with tetrahedral elements of 4 mm. The tetrahedral element is a robust and efficient element, with unique capabilities, can be used as a major element in a mesh. The number of elements and nodes are 11358 and 27472 respectively. The spring profile area is found to be critical under the stress concentration so very fine meshing is carried out in order to get the closer results.



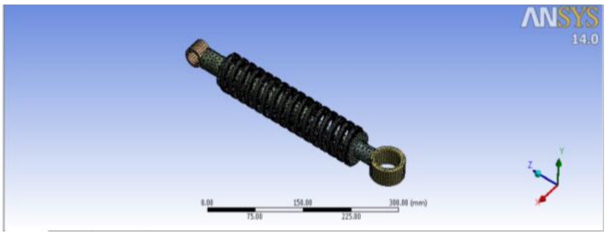



**Fig- 3:** Mesh of the different spring profile shock absorber

## 4. DESIGN AND CALCULATION OF HELICAL SPRING, SHOCK ABSORBER

Mean diameter of a coil D = 48 mm
Diameter of wire d = 8 mm
Number of turns (n) = 16
Free length (Lf) = 256 mm
Pitch (p) = 16 mm
Spring index (c = D/d) = 6
Outer diameter of spring coil (Do = D + d) = 56 mm
Total weight of (bike + 1 person +2 person) = 300 kg

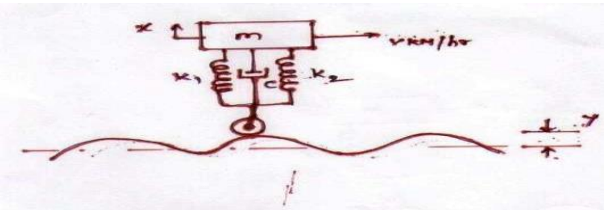


**Fig-4:** Damping force diagram

In this paper, we have an analysis of dual suspension spring CBZ extreme bike model of dual-suspension motor vehicle that can vibrate in the vertical direction while travelling over a rough road. The vehicle has masses of 300kg. The suspension system has a spring constant (spring rate) of 46714.2 N/m. We consider a damping ratio of $\xi = 0.5$. The road surface varies with an amplitude of Y = 50mm.
The frequency $\omega$ of the base excitation can be found by dividing the vehicle speed v km / hrs by the length of one cycle of road roughness.

$\Omega = 2\pi f = 2\pi\,(V \times 1000)/3600 \times (1/1) = 1.74\ v$ rad/s

$\omega = 1.74 \times 3 = 5.22$ rad/s

The natural frequency of the vehicle is given by

$\omega n = \sqrt{k/m} = \sqrt{46714.2/300} = 12.4$rad/s

Frequency ratio:-r = $\omega / \omega n = 5.22 / 12.4 = 0.42$

Amplitude ratio :-( Displacement transmissibility)

X/Y = {1 + (2ξr) 2 / (1 + r2)2+ (2ξr) 2}1/2
X/Y= {1+ (2×0.5×0.42)2/ (1+0.422)2+ (2×0.5×0.42)2}1/2
X/+Y = 1.17

Thus the displacement of a vehicle at 3 km / hrs is given by

X= 1.17 × Y = 1.07 × 0.05 = 0.0586 m = 58.6 mm
This indicates that a 50mm bump in the road is transmitted as a 58.6mm deflection to the chassis.

Forces (F) = $\delta G d^4 / 8 D^3 n$

= (58.6×42×103 × 84) / (8×483 ×6)
F = 1356.4 N

Stresses (τ) = K $(8FD/\pi d^3)$
τ = (1.25 × 8 × 1356.4×48 ) / ( π ×83 )
τ = 404.8 N/m²

## 5. Finite Element Analysis of Shock Absorber

Finite element analysis (FEA) is one of the most popular mechanical engineering applications. The finite element method is also known as problem solvers of engineering by numerical technique. This method is applicable of any complex geometry, any material properties, any boundary conditions and any loading conditions. For stress analysis, constraints are applied on the one side of spring and force is applied at the center of the other side of spring. By giving these conditions, deflection and von-misses stress are calculated on the basis of static structural analysis.

### 5.1 Static structural analysis: -

A static structural analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time- varying loads. A static analysis can, however, include steady inertia loads (such as gravity and rotational velocity), and time-varying loads that can be approximated as static equivalent loads (such as the static equivalent wind and seismic loads commonly defined in many building codes). Static analysis is used to determine the displacements, stresses, strains, and forces in structures or components caused by loads that do not include significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. The kinds of loading that can be applied in a static analysis include:

A static structural analysis can be either linear or nonlinear. All types of nonlinearities are allowed- large deformations, plasticity, creep, stress stiffening, contact (gap) elements, hyper elastic elements, etc.

### 5.1.1 Static structural analysis results for Circular profile

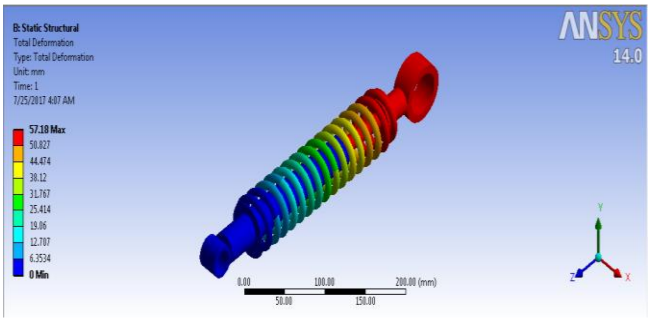



**Fig-5:** Pictorial view of Total deformation

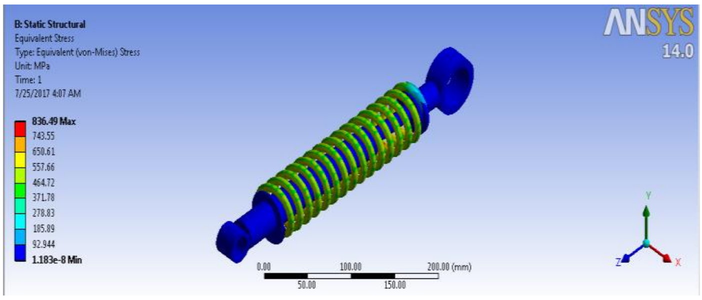



**Fig-6:** Pictorial view of Equivalent stress

### 5.1.2 Static structural analysis results for Square profile

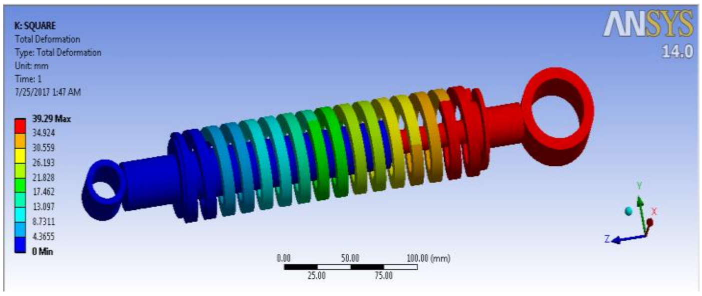



**Fig-7:** Pictorial view of Total deformation

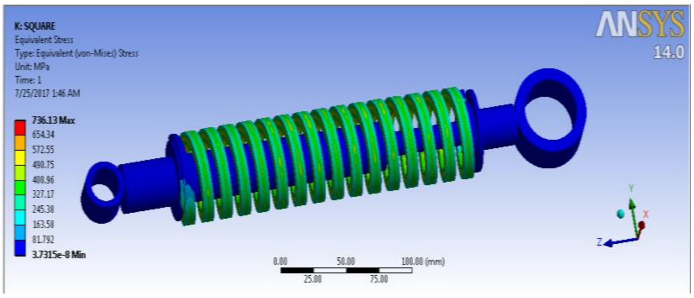



**Fig-8:** Pictorial view of Equivalent stress

### 5.1.3 Static structural analysis results for Square fillet profile

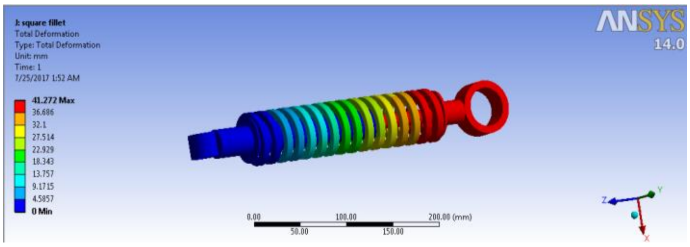



**Fig-9:** Pictorial view of Total deformation

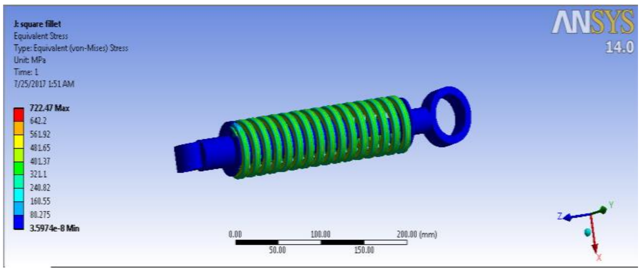



**Fig-10:** Pictorial view of Equivalent stress

## 6. Results and Discussion

### 6.1 Analysis of results obtained

The analysis has been done based on boundary conditions. The results obtained from the analysis are shown in tabular form in below sections.

### 6.1.1 Different spring profile comparison results based on static structural analysis

The calculated equivalent stress and total deformation are shown in Table 6.1. The spring profiles circular to square and square fillet static results shown in the table.

**Table -1**: Static structural analysis results

| Design | Equivalent stress (MPa) | Displacement (mm) |
|---|---|---|
| Circular | 836.49 | 57.18 |
| Square | 736.13 | 39.29 |
| Square fillet | 722.47 | 41.27 |

The minimum displacement for square profile is 39.29 mm and maximum displacement is observed at 57.18 mm for circular profile. The equivalent stress value is maximum 836.49 MPa for circular profile and minimum 722.47 mm for square fillet

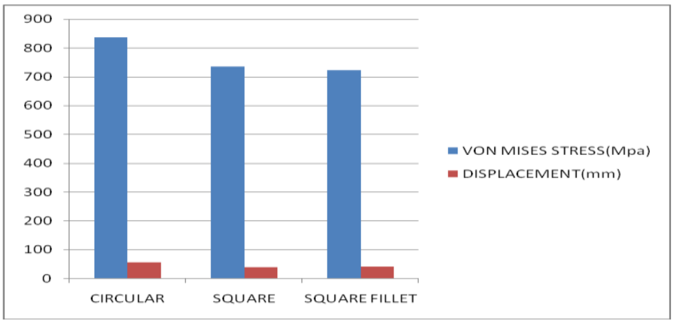



**Chart- 1:** Static analysis results comparison graph

The graph clearly indicates that equivalent stress is less for the square fillet profile and deformation is less for square profile.

## 7. CONCLUSIONS

The following are the conclusions made from the above analysis based on static structural analysis.

- Design optimization of helical spring profile results shows that, square fillet profile in static and transient analysis is better as compared to other profiles.
- From the static analysis results it is found that circular profile has 31.28% greater maximum displacement from square profile and 27.82% from square fillet and 13.63% greater maximum equivalent stress from square fillet and 12% from square profile.
- Comparing all three helical spring profile, the square fillet profile has lower result values than that of circular and square profiles.

## 8. Future scope

- In the future, there is growing opportunities for changing spring profile and use of composite materials for helical spring.
- Transient analysis of helical spring can be performed and tested in spring cases.

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## BIOGRAPHIES

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