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MODELING, ANALYSIS AND OPTIMIZATION OF COIL SPRING FOR SUSPENSION

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Abstract- *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. In this project a shock absorber is designed and a 3D model is created using CREO 3. Structural analysis and modal analysis are done on the shock absorber by varying shapes of titanium material. The analysis is done by considering loads, bike weight, persons sitting on it. Structural analysis is done to validate the strength and modal analysis is done to determine the directional deformation for different shapes of spring wire. Comparison is done for different shapes to verify best shape for spring in Shock absorber. Modeling is done in CREO 3 and analysis is done in ANSYS. CREO 3 is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design.*

Key Words: *Shock Absorber, Soil spring, Titanium ANSYS 12.0, CREO 3.0.*

I. INRODUCTION

A shock absorber or damper is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy. When a vehicle is traveling on a level road and the wheels strike a bump, the spring is compressed quickly. The compressed spring will attempt to return to its normal loaded length and, in so doing, will rebound past its normal height, causing the body to be lifted. The weight of the vehicle will then push the spring down below its normal loaded height. This, in turn, causes the spring to rebound again. This bouncing process is repeated over and over, a little less each time, until the up-and-down movement finally stops. If bouncing is allowed to go uncontrolled, it will not only cause an uncomfortable ride but will make handling of the vehicle very difficult. The design of spring in suspension system is very important.

II. LITERATURE REVIEW

Henter (1980) have invented that, when wheel is being urged out of alignment by side stress, there is a oppose flow of hydraulic fluid from one hydraulic-piston to other side of piston chamber and wheel remains at right angle to the longitudinal plane of rotation of the wheel (Henter & Warren, 1980). Chavan et al. (2013) researched on mono suspension system that it is easier to adjust. This mono suspension improves traveling, handling and decrease friction loss, and also explains when occupant run over a bump on a motorcycle with two shock absorbers, both the shock absorbers compress, but there is not at all a situation when both of them compress equally. It leads to downgrade dynamics when it comes to steadiness. But with a single shock absorber, this problem can be solved (Chavan, Margaje & Chinchorkar, 2013). Dhayakar et al. (2015) have designed and analyzed on hydraulic shock absorber in which hydraulic shock absorbers with internal coil spring let front wheel to act in response to imperfection on the road while separating the rest of the vehicle from that motion. In that design only one shock to adjust, and there are no concerns about matching two shocks (Dhayakar, Vinu, Manoj & Shanmugasundaram, 2015). Takahashi et al. (2014) have concluded in their research that when using a rectangle cross section with high rectangular ratio as a coil spring. It is much more cost effective in manufacturing than the conventional machining. It also reduces the spring constant compare to a circular cross section. Also the work-hardening enlarged the elastic limit and leading the safety of the coil spring, compared to the machined coil spring (Tsubouchi, Takahashi & Kuboki, 2014).

III. PROPERTIES OF TITANIUM

Properties Name	**Value**
Shear Stress(τ)	460 MPa
Shear Modulus (G)	44000 MPa
Poisson's Ratio	0.342

IV. DIMENSIONS OF TITANIUM SPRING

Dimensions	**Circular Wire Spring**	**Vertical Oval Wire Spring**	**Horizontal Oval Wire Spring**
Wire Diameter (mm)	11	-	-
Minor axis (mm)	11	9.6	9.6
Major axis(mm)	11	12	12
Area (mm^{2})	90.60	90.60	90.60
Pitch	20	20	20
Number Of Working Coils	12	12	12
Spring Length(mm)	260	260	260

V. THEORETICAL CALCULATION

Shear stress of titanium is 460 MPa
Taking FOS = 2
So shear stress will be 460×0.5 = 230 MPa
Taking spring index (C) = 5
Length if spring(L) = 260 mm (Nutalapati, 2016)
Calculation for loads on bike
Weight of vehicle body = 135 kg = 1323 N
Weight of person sitting on vehicle = 150 kg = 1470 N
Total load = Weight of vehicle body + Weight of person sitting on vehicle
Total load = 1323 + 1470 = 2793 N
Front Suspension = 35% of total weight = 978 N
Considering dynamic load doubled = 1956 N
For single shock absorber weight = dynamic load / 2 = 978 N
Taking Factor of Safety = 1.5
So design load on single front suspension (P) = 1467 N
No. of turns (N’) = 14
So active coils = N’- 2 = 12
Shear modulus of titanium (G) = 44000 MPa
Now,
Stress factor (K) = [(4C-1) / (4C-4)] + [0.619 / 5]
So K = 1.81

τ (shear stress) = $8\times P\times C^3\times K/\pi\times d^2$, M Pa … (1)
So $d^2 = 8\times P\times C^3\times K / \pi\times\tau$
$d^2 = 8\times1467\times5^3\times1.31 / 230\times\pi$
$d^2 = 76870.8 / 722.5$
$d^2 = 106.39\ mm^2$
So d = 10.31 ≈ 11 mm
So mean diameter of spring (D_m) = C×d = 5×11 = 55 mm
So outer diameter of spring (Do) = 5.5 + 55 = 60.5 mm

Deflection (δ) = $8\times P\times C^3\times N / G \times d$, mm … (2)
$\delta = 8\times1467\times5^3\times12 / 44000\times \pi$
δ = 17604000 / 484000 = 36.37 mm
Now pitch of the coil = 260 / (14-1) = 20
Where, δ = directional deformation (mm)
d = diameter of wire (mm)
G = shear modulus (Pa)
W = load (N)
N = number of turns

VI. MODEL CONSTRUCTION

Aim: To design a 3D model of a shock absorber by using CREO 3.0.
Equipment: Intel Core i5 computer installed with CREO 3.0.
Software: CREO 3.0
Step 1: Click Start in Menu bar > CREO 3.0 > Sketch.
Step 2: Select Sketch plane.
Step 3: Take the geometric coordinates to construct sketch window. (Nutalapati, 2016)

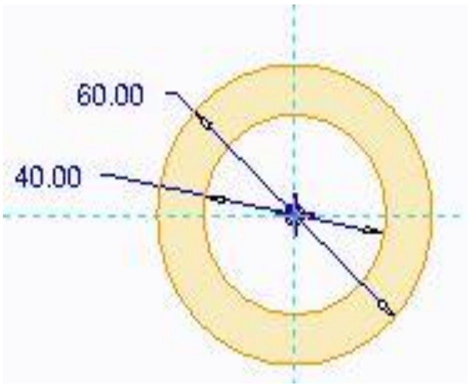

Figure 1. Top part step 1

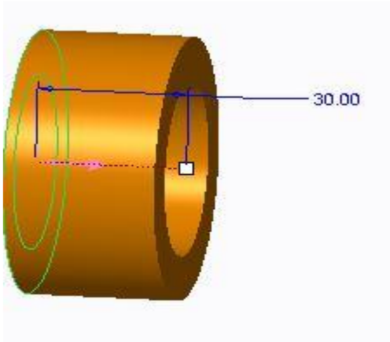

Figure 2. Top part step 2

By the definition insert, Profile, Circle, Center point (0,0) and the diameter 60.00 mm and 40.00 mm exist workbench as shown in figure 1. Then extrude to 30 mm as shown in figure 2.

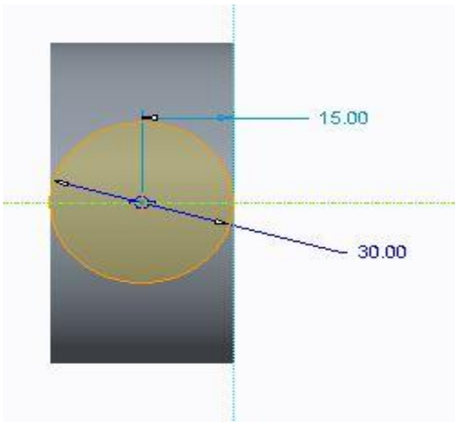

Figure 3. Top part step 3

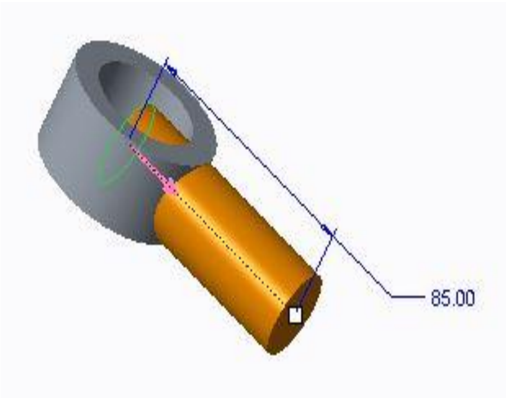

Figure 4. Top part step 4

Now select plane and draw 30 mm diameter of circle. As shown in figure 3. Now extrude that 30 mm diameter of circle to (30+55) = 85 mm as shown in figure 4. Select inner circle's trajectory and extrude it to 30 mm and select material remove option as shown in figure 5.

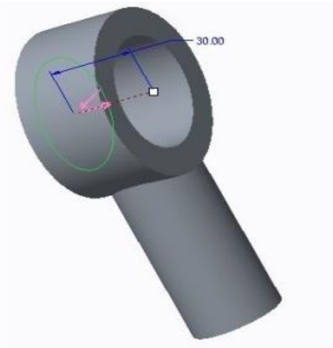

Figure 5. Top part step 5

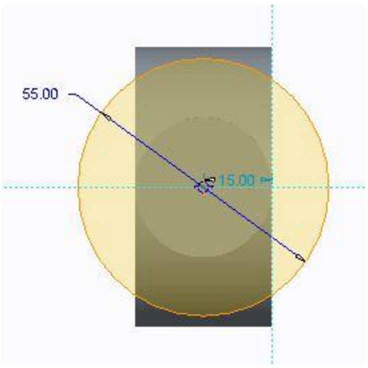

Figure 6. Top part step 6

Now select the sketch and draw a 65 mm diameter of circle and extrude it to 2 mm thickness as shown figure 6 Now select bottom of part and give definition of 30 mm and 25 mm of point circle as shown in figure 7.

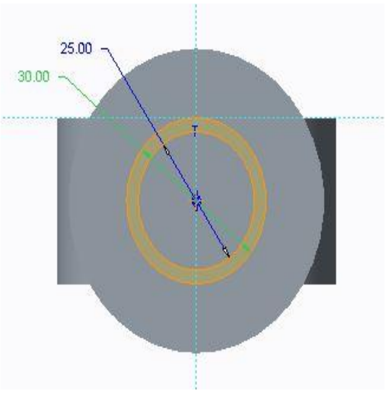

Figure 7. Top part step 7

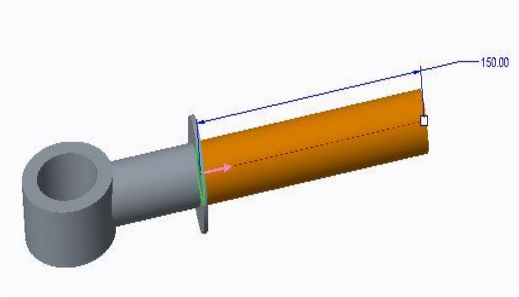

Figure 8. Top part step 8

Extrude that circle to 150 mm length as shown in figure 8.Figure 9 is final top part of suspension.

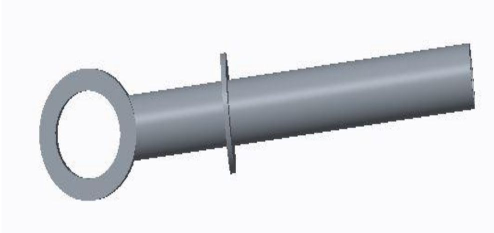

Figure 9. Final top part of suspension

Doing same procedure we can make bottom part of suspension.

Modeling of spring

Go to file > new > part > spring and define unite of measure

Insert a centre line and point definition of 30.25 mm from centre line. Define line to 260 mm length as shown in figure 10.

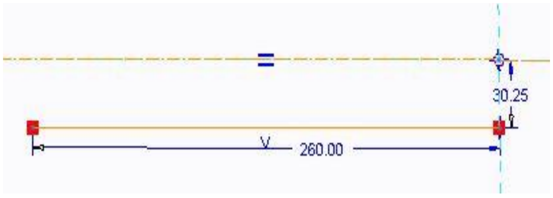

Figure 10. Spring step 1

Now exit from sketch and select helical spiral option. Then draw 11 mm diameter of circle and pitch of 20. Then accept and exit. Model will shown as figure 11.

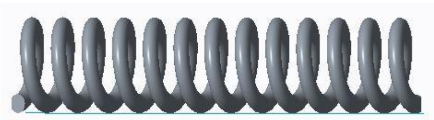

Figure 11. Final spring

Final assembly of shock absorber is shown in figure 12.

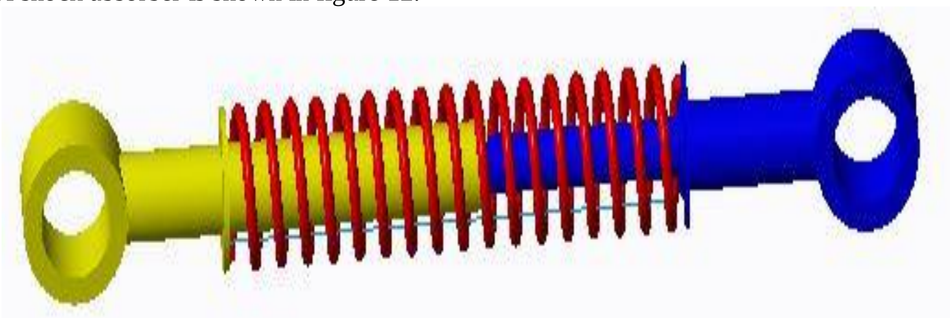

Figure 12. Final assembly

VII. ANALYSES OF WIRES

Analysis of Circular Wired Spring

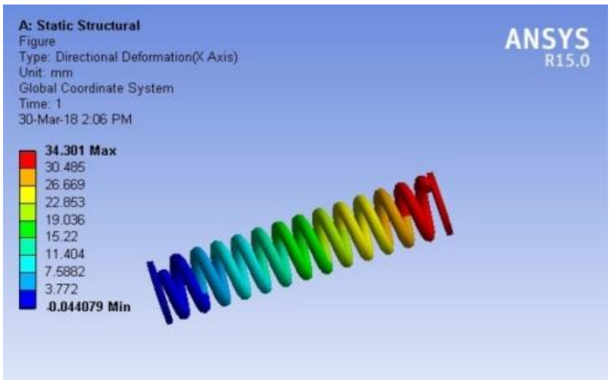

Figure 13 (A)

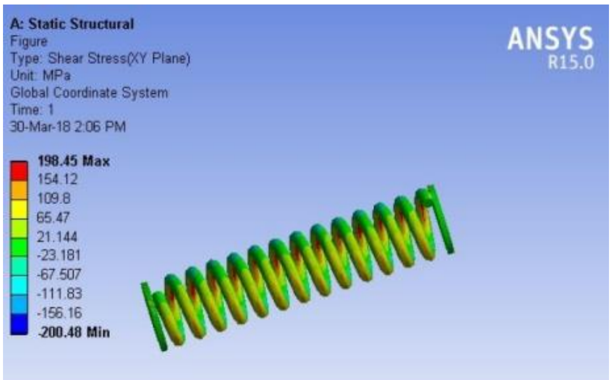

Figure 13 (B)

Figure 13 (A) and (B). Directional Deformation and Shear Stress of Circular Wired Spring Respectively.
Area of circular wire spring is 90.60 mm^2
Analysing circular springunder load of 1467 N result declared from ANSYS is below:
Directional deformtion = 30.30 mm and shear stress = 198.45 MPa.

Analysis of Horizontal Oval Wired Spring

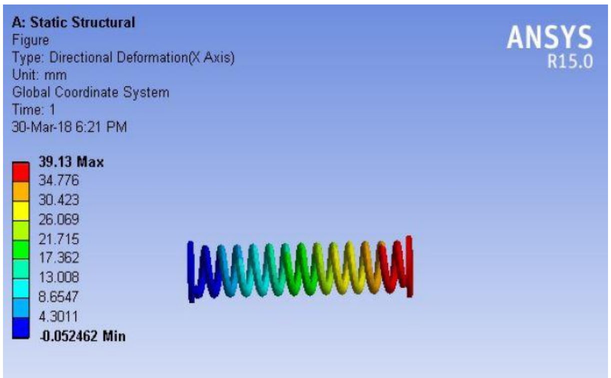

Figure 14 (A)

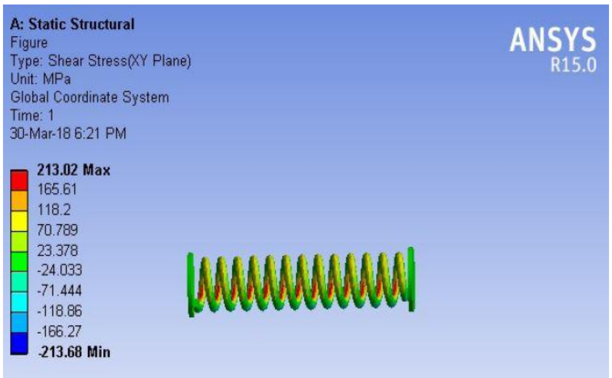

Figure 14 (B)

Figure 14 (A) and (B). Directional Deformation and Shear Stress of Horizontal Oval Wired Spring Respectively.
Taking same area as circular wired spring and analysing of horizontal oval spring under load of 1467 N result declared from ANSYS is below:
Directional deformtion = 39.30 mm and shear stress = 213.82 MPa.

Analysis of Vertical Oval Wired Spring

Figure 15 (A) and (B). Directional Deformation and Shear Stress of Vertical Oval Wired Spring Respectively
Taking same area as circular wire spring and analysing of vertical oval spring under load of 1467 N result declared from ANSYS is below: Directional deformtion = 43.60 mm and shear stress = 230.96 MPa.

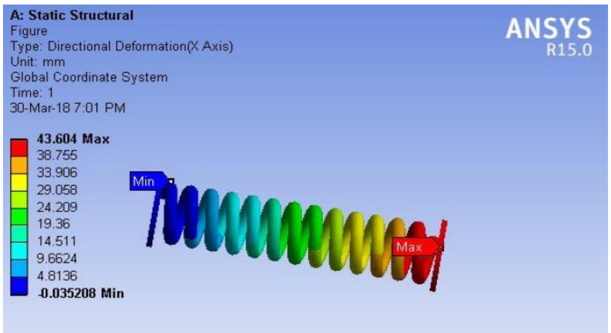

Figure 15 (A)

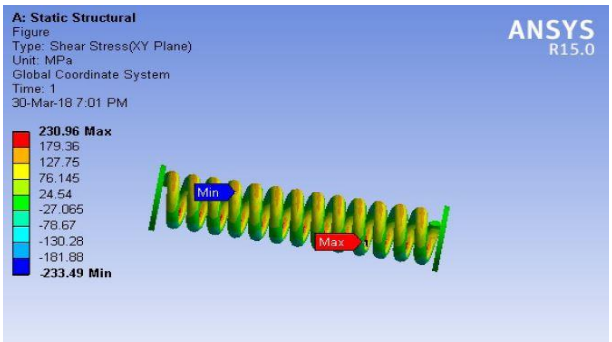

Figure 15 (B)

VIII. RESULT AND DISCUSSION

As we can see in Figure 5.2 (A) and (B) are analysis of circular wire for directional deformation and stress generated on spring under load of 1467 N. The result is nearly matched to theoretical calculation so we can say that the ANSYS analysis is valid for this analysis. Figure 5.3 (A) and (B) are analyses for horizontal oval shape of wire which have same area as circular wire .this shape giving result of directional deformation and stress generated on spring under the load of 1467NAnd Figure 5.4 (A) and (B) are analysis for vertical oval shape of wire which have same area as circular wire. This shape giving result of directional deformation and stress generated on spring under the load of 1467N.

Table 1. Comparison between theoretical calculation and FEA analysis

Shape→ Properties↓	Circular Shape		Errors
	Theoretical Data	FEA Data	
Area (mm^2)	90.60	90.60	
Load (N)	1467	1467	
Directional Deformation (mm)	36.37	30.30	6.07
Shear Stress (MPa)	202.22	198.45	3.77

Table 1 shows the comparison between theoretical calculation and FEA analysis. This table shows difference between directional deformation and shear stress between theoretical analysis of circular wire and FEA data of circular wire under same area and load.

Table 2. Comparison between three shapes of wires

Shape→ Result↓	Circular Wired Spring	Horizontal Oval Wired Spring	Vertical Oval Wired Spring
Load (N)	1467	1467	1467
Area (mm^2)	90.60	90.60	90.60
Directional Deformation (mm)	30.30	39.30	43.60
Shear Stress (MPa)	198.45	213.18	230.96

Table 2 shows Comparison between three shapes of wires. Spring of circular wire has 30.30 mm directional deformation and shear stress is 198.45 MPa which results are nearly matches to theoretical calculation. So we can say the ANSYS and theoretical analysis results are valid for further analysis for vertical oval wired spring and horizontal oval wired spring. By comparing horizontal oval wired spring with circular wired spring, difference between directional deformations is 9 mm and difference between shear stress is 14.73 MPa. And by comparing vertical oval wired spring with circular wired spring, difference between directional deformations is 13.3 mm and difference between shear stress is 31.55 MPa.
As by comparison between three shapes circular shape wire spring generate less stress and less directional deformation. So using circular wired shape spring is best suited for spring. With requirement of less stiffness,horizontal oval spring can be used without breaking spring.

IX. CONCLUSION

From the theoretical calculation and ANSYS analysis result, the conclusion derived is as follow:

- Comparing FEA data between three shapes of wire (circular, vertical oval and horizontal oval) circular shape wire is best suited for practical use as coil spring suspension for high stiffness requirement. When using circular shape wire shear stress is produced 202.22 MPa in theoretical analysis and 198.45 MPa in FEA analysis with directional deformation of 36.37 mm and 30.30 mm respectively.
- Horizontal oval shape wire spring can be used for practical use with requirement of less stiffness in spring without breaking spring. By comparing vertical oval wired spring with circular wired spring as Table 6.2, difference between directional deformations is 9 mm and difference between shear stress is 14.73 MPa.
- Vertical wired shaped spring can’t be used in practical use, because its shear stress is more than limit of spring’s shear stress. And by comparing horizontal oval wired spring with circular wired spring, difference between directional deformations is 13.3 mm and difference between shear stress is 31.55 MPa.

REFERENCES:

1. Bharambe, A. (2016). Magnetic Suspension for Motorcycles, *5*(9), 1092–1097
2. Chavan, P. D. K., Margaje, S. V, & Chinchorkar, P. A. (2013). Suspension in Bikes Considering Preload , Damping Parameters and Employment of Mono Suspension in Recent Bikes, *4*, 212–218.
3. Dhayakar, K., Vinu, T., Manoj, R. S., & Shanmugasundaram, S. (2015). Design and Analysis of Front Mono Suspension in Motorcycle 1, *12*(2), 84–100.
4. Dohmen, Borin, & Zubarev, 2017; Jonasson & Roos, 2008; Sun, Fang, & Chen, 2016; Zhang, Chen, Guo, Zhang, & Eben, 2017
5. Elankovan, M. G. (2015). Conceptual Design of Electromagnetic Damper for Motorcycle Suspension System, *4*(8), 472–476.
6. Henter, T. C., & Warren, E. (1980). United States Patent 191.
7. Sun, N., Fang, Y., & Chen, H. (2016). Control Engineering Practice Tracking control for magnetic-suspension systems with online unknown mass identi fi cation. *Control Engineering Practice*, (2013).
8. Tandel, S., Desai, B., Desai, A., Shirsat, A., & Tambe, D. (2015). Design and Fabrication of Magnetic Suspension, *3*(4), 144–148.
9. Tsubouchi, T., Takahashi, K., & Kuboki, T. (2014). Development of coiled springs with high rectangular ratio in cross-section. *Procedia Engineering*, *81*(October), 574–579.
10. Zhang, Y., Chen, H., Guo, K., Zhang, X., & Eben, S. (2017). Electro-hydraulic damper for energy harvesting suspension : Modeling , prototyping and experimental validation. *Applied Energy*, *199*, 1–12.

