

Fatigue Analysis and Modal Analysis of Helical coil Compression Spring

Pangunuri Sai Sharath Chander Rao¹, Putti Srinivasa Rao²

¹ Post Graduation student, Department of Mechanical Engineering [machine design], Andhra University, Visakhapatnam, Andhra Pradesh, India

² Professor, Department of Mechanical Engineering [machine design], Andhra University, Visakhapatnam, Andhra Pradesh, India

Abstract—Helical coil compression spring in the two-wheeler suspension is generally subjected to the cyclic loads and compression loads due to the rough surfaces, uneven roads and sometimes vibrations caused by the vehicle itself. So, here we will be taking Chromium Vanadium ASTM A231, Chromium silicon ASTM A401 and Steel wire ASTM A227 which are considered to withstand cyclic loads and shows good fatigue life. We will take ASTM standard wire diameter and maximum tensile strength for its given diameter from 8mm to 12mm. As we are doing the analysis for the Fatigue life cycles, we should be considering the suitable spring index to withstand the cyclic loads, as from the design data book spring index 6 to 9 is best for the fatigue loads. Now we get the Base Spring dimensions, for each material there will be 20 Cases and for the three materials we are considering will add up to 60 Cases Total. For the load considerations we will be considering for two persons where each person's weight is 85kg respectively and the two-wheeler itself weighs 150kg then the total load sums up to 320kg. In the two-wheeler there are two suspension systems – Front suspension system and Rear suspension system here we are considering only the rear suspension system where the 70% of the total load is applied on it. Then the total load applied on suspension is 224kg \approx 1100N. By using the design formulae for springs, we will calculate its Total deformation, Shear stresses, Stiffness of the spring, Fatigue life and Natural frequency of the Helical coil compression springs for each taken material. Now, Build the Helical Spring model in the Numerical software, we will be using ANSYS R23 for Geometry and Modelling. Then do the meshing with tetrahedron elements with the element size of 1mm. After that, fix the bottom of spring with the fixed support and create the remote point at the center of the spring where overall load is acted on it. Now apply the load of 1100N for two persons and solve the Modal. After the analysis is done results will be obtained for the Total deformations, Shear stress, Fatigue cycles and natural frequencies. Now compare the both obtained results so that we can find the fatigue life, natural frequency for the Helical Spring and based on these values we can determine the optimized Dimensions of a Helical coil compression spring for this load.

Index Terms—Helical coil compression spring, Fatigue strength coefficient, Fatigue life and Natural frequency

I. INTRODUCTION

A Helical coil compression spring is a type of mechanical spring characterized by its spiral shape, designed to store and release energy through axial compression. Typically made from high-strength steel wire, these springs compress when subjected to axial loads, allowing them to absorb energy and return to their original length once the load is removed. Helical coil compression springs are widely used in various applications, including automotive suspensions, industrial machinery, and consumer products, due to their effective energy storage capabilities and versatility in design. Their performance can be tailored by adjusting factors such as wire diameter, coil diameter, and the number of active coils, making them integral components in modern engineering solutions.



The design process of helical coil compression springs is a critical phase in ensuring that the springs meet specific performance requirements for various applications. This process involves several detailed steps, each contributing to the optimal functionality, durability, and efficiency of the spring. Mainly the materials used in manufacturing of a Helical coil compression spring.

- a. Selection of materials for Helical Spring:
ASTM A231 is a specification for high-strength, low-alloy steel, primarily used for the manufacture of

structural components in buildings and bridges. Here is a table summarizing the mechanical properties of ASTM A231 steel:

Table 1: Properties of the ASTM A231 material

Mechanical Property	Value
Yield Tensile Strength	924 - 1442 MPa
Maximum Tensile Strength	1320 - 2060 MPa
Elongation	20% minimum
Reduction of Area	50% minimum
Modulus of Elasticity	207 GPa
Poisson's Ratio	0.26 - 0.30
Brinell Hardness	155 - 235 HB

ASTM A401 is a specification for high-strength carbon steel used primarily in the manufacture of mechanical springs. The following table summarizes the typical mechanical properties associated with ASTM A401 steel:

Table 2: Properties of the ASTM A401 material

Mechanical Property	Value
Yield Tensile Strength	1071 - 1456 MPa
Maximum Tensile Strength	1530 - 2080 MPa
Elongation	10% minimum
Reduction of Area	40% minimum
Brinell Hardness	200 - 300 HB
Modulus of Elasticity	200 GPa
Poisson's Ratio	0.26 - 0.30

ASTM A227 is a specification for steel wire used in various applications, particularly for cold heading and forming. It covers wire of various diameters and grades, but the primary focus is on the mechanical properties of the wire. The following table summarizes the typical mechanical properties associated with ASTM A227 steel:

Table 3: Properties of the ASTM A227 material

Mechanical Property	Value
Yield Tensile Strength	819 - 1568 MPa
Maximum Tensile Strength	1170 - 2240 MPa
Elongation	10% minimum

Reduction of Area	30% minimum
Brinell Hardness	200 - 300 HB
Modulus of Elasticity	200 GPa
Poisson's Ratio	0.26 - 0.30

b. Formulae used in designing of Helical coil compression spring:

- Wire Diameter [d]
- Mean Coil Diameter [D]
- Spring Index [C] = $\left[\frac{D}{d}\right]$
- Wahl's stress factor $[K_s] = \left[\frac{4C-1}{4C-4}\right] + \left[\frac{0.615}{C}\right]$
- Spring Stiffness [K] = $\left[\frac{G d^4}{8D^3 N_a}\right]$
- Shear Stress $[\tau] = \left[\frac{8WC}{\pi d^2}\right] k_s$
- Deflection of the spring $[\delta] = \left[\frac{8WD^3 N_a}{G d^4}\right]$
- Fatigue strength coefficient [f]
- S-N curve coefficient [a] = $\left[\frac{f \cdot UTS^2}{\tau_{max}}\right]$
- S-N curve exponent [b] = $\left[\frac{1}{3} \cdot \log \left[\frac{f \cdot UTS}{\tau_{max}}\right]\right]$
- Modified fatigue strength $[f_{prime}] = [f \cdot \tau_e]$
- Fatigue Life $[N_{f_{avg}}] = a \cdot \left[\frac{f_{prime} [UTS - \tau_{max}]}{\tau_{max}^{5y}}\right]^{\frac{1}{b}}$
- Natural Frequency $[f_n] = \left[\frac{1}{2\pi} \sqrt{\frac{K}{m}}\right]$

II. PROCEDURE

Standard design formulae have been followed from the standard books to design springs. For having better quality of spring, the value of spring index was to be maintained in the range of 6-9 which offered best fatigue life manufacturing rate at lower cost. On the basis of given range of spring index, the other parameters like (outer diameter, height of the spring, wire diameter, the number of coils, etc.) were decided. As the spring index selected for this research work was 6-9 and the spring wire diameter was taken from ASTM standards 8-12 which offered best manufacturing rate at lower cost. Therefore, each material will get 20cases to consider and a total of 60cases to calculate.

a. Load Considerations:

By considering a two-wheeler of an average weight of 150Kgs and carrying a couple of persons where each weigh 85Kgs respectively, Now, the total load on the suspension springs including the bike load

$$W_t = 150 + 85 + 85$$

$$W_t = 320 \text{ Kgs}$$

Here, we are considering only rear suspension where it bears of 70% of the total load.

$$W_r = [(70\%) * 320\text{Kgs}]$$

$$W_r = 224 \text{ Kgs}$$

Since, the two-wheeler has a dual suspension spring in the rear the rear load is equally divided between the two.

$$W = 224/2 = 112\text{Kgs}$$

$$W \approx 1100 \text{ N}$$

b. Analytical Analysis on Helical coil compression spring:

For case 1 for ASTM A231 spring index, 6; spring wire diameter, 8; the following data was used: Mean diameter of spring, 48 mm; Maximum tensile strength, 1540 MPa; Maximum shear stress, 770 MPa; Weight of spring (W), 112 kg or force applied, 1100 N; and Numbers of coils (n), 17

- Wire diameter [d] = 8mm
- Spring Index [C]= 6
- Mean Diameter [D]= 48mm
- Applied Load [W]= 1100N
- Total no. of coils [N_t]= 17
- Active coils [N]= 15
- Density [ρ]= 7800 kg.m⁻³
- Fatigue strength Coeff. [f]= 0.7~0.9
- Whal's stress factor [k_s]= $\left[\frac{4C-1}{4C-4}\right] + \left[\frac{0.615}{C}\right] = 1.2525$
- Solid Length [L_s] = [Nd] = 136mm
- Deflection [δ] = $\left[\frac{8WD^3Na}{Gd^4}\right] = \left[\frac{8*1100(48^3)15}{79615*(8^4)}\right] = 44.94\text{mm}$
- Free Length [L_f] = [L_s + [N - 1] + δ] = 136 + (17-1) + 44.94 = 196.94mm
- Shear Stress [τ] = $\left[\frac{8WC}{\pi d^2}\right] k_s = 328.91\text{MPa}$
- Stiffness of the spring [K] = $\frac{G d^4}{8D^3 N_a} = \frac{(79615)8^4}{8(48^3)15} = 23036.74\text{N/m}$
- S-N curve coefficient [a]= $\frac{[f \cdot UTS]^2}{\tau_{max}} = 2494.8$
- S-N curve exponent [b]= $\left[\frac{1}{3} \cdot \log \left[\frac{f \cdot UTS}{\tau_{max}}\right]\right] = -0.085$
- Fatigue life [N_{favg}] = $a \cdot \left[\frac{f_{prime}[UTS - \tau_{max}]}{\tau_{max}^{Sy}}\right]^{\frac{1}{b}} = 9.93\text{E}+06 \text{ cycles}$
- Volume of the spring [V] = $\left[\frac{\pi d^2 DN}{4}\right] = 4.1\text{E}-5 \text{ m}^3$

- Mass of the spring [m] = ρv = 0.3199Kg
- Natural frequency [f_n] = $\left[\frac{1}{2\pi} \sqrt{\frac{k}{m}}\right] = 42.71\text{Hz}$

Since the Deflection and Shear stress of the spring is more for the spring wire diameter 8mm and 9mm we will consider 10mm, 11mm, 12mm for our design analysis and with the spring index varying from 6–9 then the calculated results are tabulated in the below table:

Table 4: Analytical Analysis for the material ASTM A231

d= (mm)	D= (mm)	δ = (mm)	τ = (MPa)	N _{favg} = (cycles)	f _n = (Hz)
10	60	35.95	210.5	1.80E+05	34.17
10	70	57.09	237.8	2.29E+05	25.10
10	80	85.22	265.3	3.54E+05	19.22
10	90	121.34	292.9	4.25E+05	15.18
11	66	32.68	173.9	1.41E+05	31.06
11	77	51.90	196.5	2.33E+05	22.82
11	88	77.47	219.2	3.44E+05	17.47
11	99	110.31	242.1	4.58E+05	13.80
12	72	29.96	146.1	1.32E+05	28.47
12	84	47.57	165.1	2.14E+05	20.92
12	96	71.02	184.2	3.14E+05	16.02
12	108	101.12	203.4	3.81E+05	12.65

Table 5: Analytical Analysis for the material ASTM A401

d= (mm)	D= (mm)	δ = (mm)	τ = (MPa)	N _{favg} = (cycles)	f _n = (Hz)
10	60	37.06	210.5	7.67E+04	34.06
10	70	58.85	237.7	1.24E+05	25.02
10	80	87.85	265.3	1.74E+05	19.16
10	90	125.09	292.9	2.24E+05	15.14
11	66	33.69	173.9	7.38E+04	30.96
11	77	53.50	196.5	1.22E+05	22.75
11	88	79.87	219.2	1.73E+05	17.42
11	99	113.72	242.1	2.32E+05	13.76
12	72	30.88	146.1	6.79E+04	28.38
12	84	49.04	165.1	1.08E+05	20.85
12	96	73.21	184.2	1.46E+05	15.96
12	108	104.24	203.4	1.95E+05	12.61

Table 6: Analytical Analysis for the material ASTM A227

d= (mm)	D= (mm)	δ = (mm)	τ = (MPa)	N _{favg} = (cycles)	f _n = (Hz)
10	60	37.07	210.50	6.90E+04	34.06
10	70	58.86	237.82	1.27E+05	25.02
10	80	87.86	265.33	1.65E+05	19.16
10	90	125.10	292.96	2.14E+05	15.14
11	66	33.70	173.97	1.20E+05	30.96

11	77	53.51	196.54	1.44E+05	22.75
11	88	79.87	219.28	1.62E+05	17.42
11	99	113.72	242.12	2.28E+05	13.76
12	72	30.89	146.18	5.80E+04	28.38
12	84	49.05	165.15	1.09E+05	20.85
12	96	73.22	184.25	1.51E+05	15.96
12	108	104.25	203.45	1.87E+05	12.61

From the above Tables 4, 5, 6 we have observed that, as the Wire diameter increases the fatigue life is gradually decreasing, and we can also observe that at spring index 7, 8, 9 at the wire diameter 11mm a slight increase in the fatigue life while comparing to wire diameter 10mm and 12mm, while at the spring index 6 has the fatigue gradually decreases. As the Spring index increases, we can see the best wire diameter for the applied load 1100N is 11mm.

c. Numerical Analysis on Helical coil compression spring:

The steps involved in Numerical Analysis are as follows:

- Pre-Processing
 1. Initial setup
 2. Geometrical modelling,
 3. Meshing,
 4. Loading setup and solve.
- Post-Processing
 5. Review results

1.Initial setup

Starting ANSYS 2023 R1 Workbench by selecting the program from start menu Start > All Programs > ANSYS 2023 R1> Workbench. Selecting the preferred analysis (Structural Analysis) from the Work-bench tool box and then specifying the required material properties to perform structural analysis using engineering data module. In present work structural analysis was performed for chromium vanadium ASTM A231. The dimensions of the spring were d= 8mm, C=6, N=17, D=48mm. According to the ASTM standard specifications, material properties are tabulated in Table 1.

2.Geometrical Modelling

The geometric model was developed using ANSYS WORKBENCH 2023 R1. GEOMETRY was used to create geometric model for helical spring with all dimensions. First, we need to select a plane and draw the profile for the spring (circle) at a given dimensions here we are taking wire diameter = 8mm, mean diameter = 48mm. now, click on the new sketch to open a new sketcher in the same plane and draw the

axis of the spring where the spring profile revolve around the axis. After the sketching we need to generate the spring along the drawn axis with the circular profile for this we will be using SWEEP command.

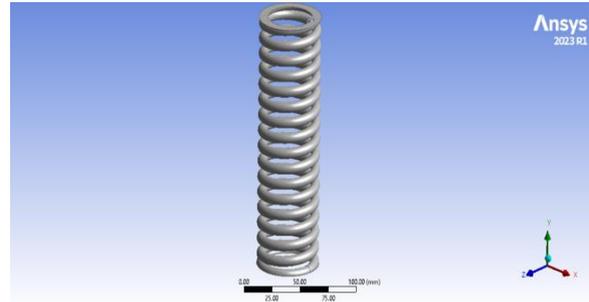


Figure 2: Geometry model of the spring in ANSYS.

3.Meshing

This model is meshed with tetrahedron elements with 10 nodes and 6 degrees of freedom for each node. MESH200 is a "mesh-only" element, contributing nothing to the solution. This element can be used for the following types of operations (1). Multistep meshing operations, such as extrusion, that requires a lower dimensionality mesh be used for the creation of a higher dimensionality mesh. (2). Line-meshing in 2-D or 3-D space with or without mid-side nodes. (3). Area-meshing or volume-meshing in 3-D space with triangles, quadrilaterals, tetrahedral, or bricks, with or without mid-side nodes. (4). Temporary storage of elements when the analysis physics has not yet been specified.

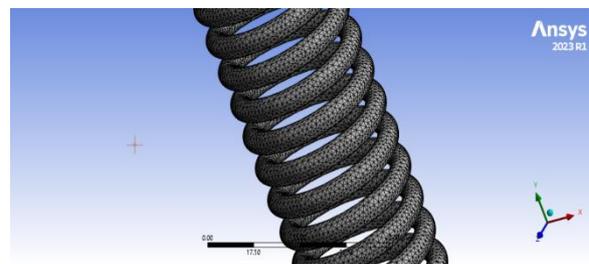


Figure 3: Meshing of elements with the tetrahedron elements



Figure 4: Meshing of elements for the whole helical spring

4.Loading setup and Solving

In this we need to set up a fixed support at the end Base of the spring and Load is applied in the -Y direction through a remote point. The remote point is generally used when the applied load needs to be distributed uniformly along the surface of the body. Then the remote point is set in the -Y direction at the centre of the spring and 1100N load is applied. Then the solution input is given that is, Total deformation, shear stress, Fatigue cycles. For the Fatigue cycles we need to use the fatigue tool in which we have to give the S-N curves of the particular material here we are taking ASTM A231. After that run the solution.

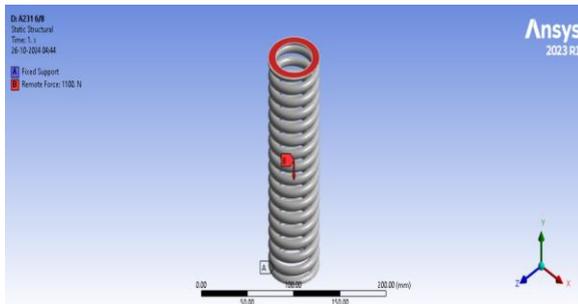


Figure 5: Fixed support at the bottom and remote point at centre

5. Review Results

To extract the generated Total deformations, Shear stress, Fatigue Life Cycles. The generated deformation is shown in the Figure 6.

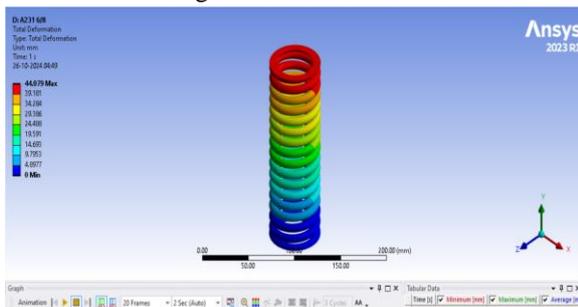


Figure 6: Total deformation of a Helical coil spring

In this research work Numerical analysis was performed on chromium vanadium [ASTM A231], chromium silicon [ASTM A401], steel wire [ASTM A227] three materials for Helical coil compression springs. The dimensions of the spring vary Wire diameter increases from 10mm to 12mm, Spring index increases from 6 to 9, Number of coils will remain constant = 17, Mean coil Diameter vary with respect to the wire diameter and spring index.

Table 7: Numerical Analysis of a Helical Spring using ASTM A231 in ANSYS

d= (mm)	D= (mm)	δ = (mm)	τ = (MPa)	N_{favg} = (cycles)	f_n = (Hz)
10	60	35.34	208.34	1.51E+05	32.5
10	70	56.29	236.9	2.48E+05	23.7
10	80	84.72	265.16	3.38E+05	18.01
10	90	123.86	294.99	4.47E+05	14.06
11	66	32.13	173.13	1.45E+05	29.58
11	77	51.19	195.61	2.41E+05	21.6
11	88	76.07	218.56	3.50E+05	16.49
11	99	110.01	242.13	4.66E+05	12.93
12	72	29.45	147.56	1.32E+05	27.15
12	84	47.27	164.44	2.14E+05	19.73
12	96	71.12	184.18	3.13E+05	14.96
12	108	100.43	203.05	3.88E+05	11.84

Table 8: Numerical Analysis of a Helical Spring using ASTM A401 in ANSYS

d= (mm)	D= (mm)	δ = (mm)	τ = (MPa)	N_{favg} = (cycles)	f_n = (Hz)
10	60	36.58	208.34	7.82E+04	31.84
10	70	58.26	236.9	1.27E+05	23.22
10	80	87.69	263.8	1.70E+05	17.64
10	90	127.03	359.91	2.23E+05	13.78
11	66	33.26	173.13	7.52E+04	28.98
11	77	52.99	195.61	1.22E+05	21.16
11	88	78.73	218.56	1.76E+05	16.16
11	99	113.86	242.13	2.34E+05	12.67
12	72	30.49	147.56	6.86E+04	26.6
12	84	48.93	164.44	1.09E+05	19.34
12	96	73.61	184.18	1.58E+05	14.66
12	108	103.94	203.05	1.95E+05	11.6

Table 9: Numerical Analysis of a Helical Spring using ASTM A227 in ANSYS

d= (mm)	D= (mm)	δ = (mm)	τ = (MPa)	N_{favg} = (cycles)	f_n = (Hz)
10	60	36.58	208.34	6.86E+04	31.84
10	70	58.26	236.9	1.21E+05	23.22
10	80	87.69	265.16	1.62E+05	17.64
10	90	128.19	294.99	2.17E+05	13.78
11	66	33.26	173.13	6.61E+04	28.98
11	77	52.99	195.61	1.16E+05	21.16
11	88	78.73	218.56	1.69E+05	16.16
11	99	113.86	242.13	2.28E+05	12.67
12	72	30.49	147.56	5.94E+04	26.6
12	84	48.93	164.44	1.02E+05	19.34
12	96	73.61	184.18	1.51E+05	14.66
12	108	103.94	203.05	1.89E+05	11.6

From the above Tables 7, 8, 9 we have observed that, as the Wire diameter increases the fatigue life is gradually decreasing, and we can also observe that at spring index 8, 9 at the wire diameter 11mm a slight increase in the fatigue life while comparing to wire

diameter 10mm and 12mm, while at the spring index 6, 7 has the fatigue gradually decreases. As the Spring index increases, we can see the best wire diameter for the applied load 1100N is 11mm.

III. RESULTS AND DISCUSSION

From Analytical Analysis (Theoretical Analysis) and Numerical Analysis (ANSYS Analysis) by Structural analysis and modal analysis Total deformations, Shear stresses, Fatigue life, natural frequencies are obtained for Helical coil Compression springs. Comparison for both Analytical and Numerical Analysis on Fatigue life and natural frequencies of Helical coil Compression springs are done.

Table 10: Comparison of Numerical Analysis [ANSYS] VS Analytical Analysis [Theoretical] for ASTM A231 Helical coil Compression springs

d= (mm)	C=	Average fatigue life N_{avg} = (cycles)		Natural frequency f_n = (Hz)	
		Numerical	Analytical	Num.	Ana.
10	6	1.51E+05	1.80E+05	32.5	34.17
10	7	2.48E+05	2.29E+05	23.7	25.10
10	8	3.38E+05	3.54E+05	18.01	19.22
10	9	4.47E+05	4.25E+05	14.06	15.18
11	6	1.45E+05	1.41E+05	29.58	31.06
11	7	2.41E+05	2.33E+05	21.6	22.82
11	8	3.50E+05	3.44E+05	16.49	17.47
11	9	4.66E+05	4.58E+05	12.93	13.80
12	6	1.32E+05	1.32E+05	27.15	28.47
12	7	2.14E+05	2.14E+05	19.73	20.92
12	8	3.13E+05	3.14E+05	14.96	16.02
12	9	3.88E+05	3.81E+05	11.84	12.65

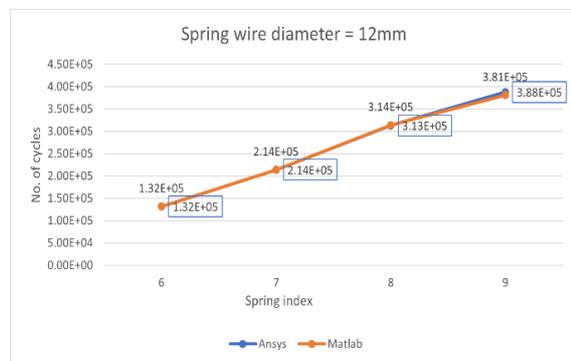


Figure 7: No. of Cycles VS Spring index at 12mm wire diameter ASTM A231

From the above Graph figure 7, we have observed that, as the spring index increases the fatigue life also gradually increases and as the wire diameter increases

the error percentage in the results for theoretical and ANSYS has also gradually decreased.

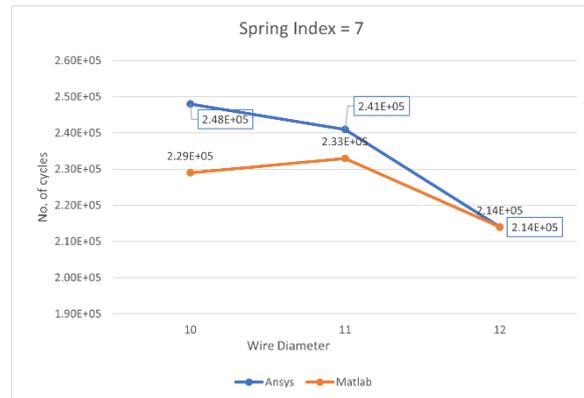


Figure 8: No. of Cycles VS Wire diameter at 7 Spring index ASTM A231

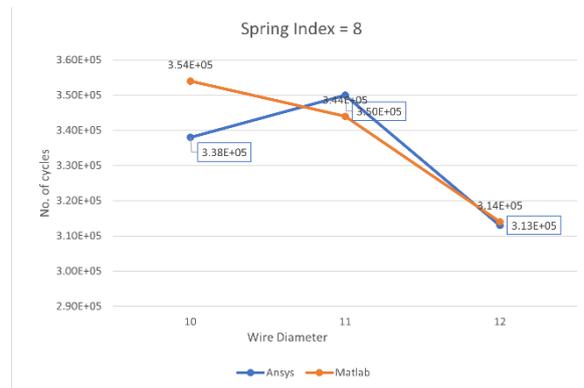


Figure 9: No. of Cycles VS Wire diameter at 8 Spring index ASTM A231

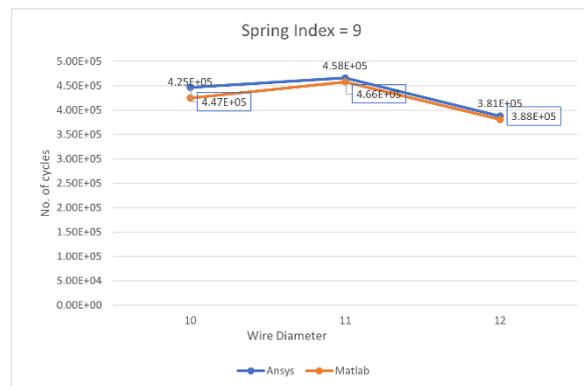


Figure 10: No. of Cycles VS Wire diameter at 9 Spring index ASTM A231

From the above Graphs we have observed that, as the Wire diameter increases the fatigue life is gradually decreasing, and we can also observe that at the wire diameter 11mm has a slight increase in the fatigue life while comparing to wire diameter 10mm and 12mm. As the wire diameter increases the error percentage in the results for theoretical and ANSYS has also gradually decreased.

Table 11: Comparison of Numerical Analysis [ANSYS] VS Analytical Analysis [Theoretical] for ASTM A401 Helical coil Compression springs

d=(mm)	C=	Average fatigue life N_{favg} = (cycles)		Natural frequency f_n = (Hz)	
		Numerical	Analytical	Num.	Ana.
10	6	7.82E+04	7.67E+04	31.84	34.06
10	7	1.27E+05	1.24E+05	23.22	25.02
10	8	1.70E+05	1.74E+05	17.64	19.16
10	9	2.23E+05	2.24E+05	13.78	15.14
11	6	7.52E+04	7.38E+04	28.98	30.96
11	7	1.22E+05	1.22E+05	21.16	22.75
11	8	1.76E+05	1.73E+05	16.16	17.42
11	9	2.34E+05	2.32E+05	12.67	13.76
12	6	6.86E+04	6.79E+04	26.6	28.38
12	7	1.09E+05	1.08E+05	19.34	20.85
12	8	1.58E+05	1.46E+05	14.66	15.96
12	9	1.95E+05	1.95E+05	11.6	12.61

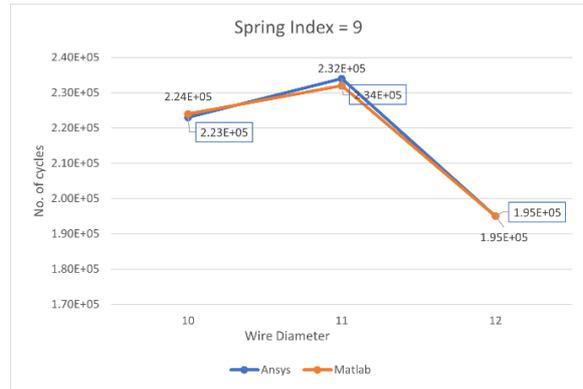


Figure 13: No. of Cycles VS Wire diameter at 9 Spring index ASTM A401

From the above Graphs we have observed that, as the Wire diameter increases the fatigue life is gradually decreasing, and we can also observe that at spring index 9 at the wire diameter 11mm a slight increase in the fatigue life while comparing to wire diameter 10mm and 12mm, while at the spring index 6, 7, 8 has the fatigue gradually decreases. As the wire diameter increases the error percentage in the results for theoretical and ANSYS has also gradually decreased.

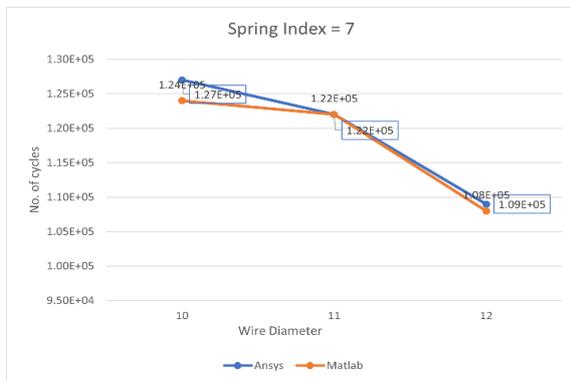


Figure 11: No. of Cycles VS Wire diameter at 7 Spring index ASTM A401

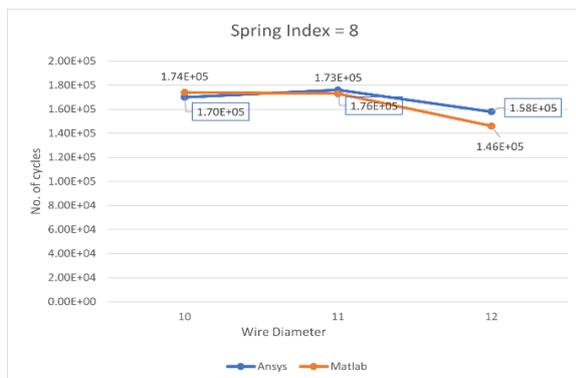


Figure 12: No. of Cycles VS Wire diameter at 8 Spring index ASTM A401

Table 12: Comparison of Numerical Analysis [ANSYS] VS Analytical Analysis [Theoretical] for ASTM A227 Helical coil Compression springs

d=(mm)	C=	Average fatigue life N_{favg} = (cycles)		Natural frequency f_n = (Hz)	
		Numerical	Analytical	Num.	Ana.
10	6	6.86E+04	6.90E+04	31.84	34.06
10	7	1.21E+05	1.27E+05	23.22	25.02
10	8	1.62E+05	1.65E+05	17.64	19.16
10	9	2.17E+05	2.14E+05	13.78	15.14
11	6	6.61E+04	6.32E+04	28.98	30.96
11	7	1.16E+05	1.44E+05	21.16	22.75
11	8	1.69E+05	1.62E+05	16.16	17.42
11	9	2.28E+05	2.28E+05	12.67	13.76
12	6	5.94E+04	5.80E+04	26.6	28.38
12	7	1.02E+05	1.09E+05	19.34	20.85
12	8	1.51E+05	1.51E+05	14.66	15.96
12	9	1.89E+05	1.87E+05	11.6	12.61

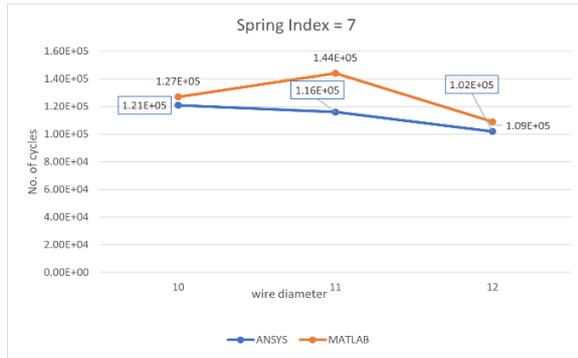


Figure 14: No of Cycles VS Wire diameter at 7 Spring index ASTM A227.

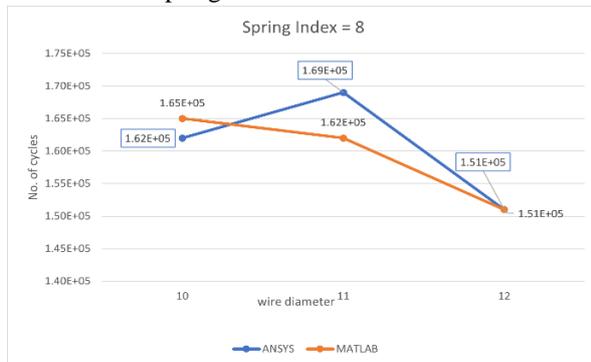


Figure 15: No of Cycles VS Wire diameter at 8 Spring index ASTM A227.

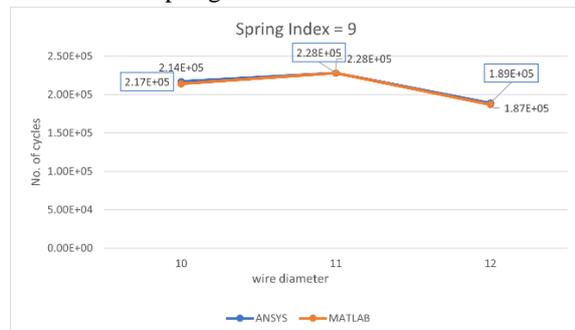


Figure 16: No of Cycles VS Wire diameter at 9 Spring index ASTM A227.

From the above Graphs we have observed that, as the Wire diameter increases the fatigue life is gradually decreasing, and we can also observe that at spring index 7, 8, 9 at the wire diameter 11mm a slight increase in the fatigue life while comparing to wire diameter 10mm and 12mm, while at the spring index 6 has the fatigue gradually decreases.

IV. CONCLUSION

In this Thesis, Fatigue Life Cycles, Modal Analysis and Design optimization of the Helical Coil Compression Spring with three different types of materials – ASTM A231, ASTM A401 ASTM A227 is studied. In an investigation into the deviations in the fatigue life cycles with respect to the spring index as

well as with respect to the wire diameter of the spring at each given material are investigated Numerically and Verified Analytically.

- The Structural analysis and Modal analysis for a Helical Coil Compression Spring, conducted using ANSYS, has been validated with theoretical results. The Fatigue life cycles closely match the theoretical and experimental values, as shown in Tables 10, 11, 12.
- In this fatigue life analysis, as the Helical Coil Compression Spring Wire diameter increases the fatigue life is gradually decreasing, and we can also observe that at the wire diameter 11mm has a slight increase in the fatigue life while comparing to wire diameter 10mm and 12mm at any given spring index.
- Similarly, as the wire diameter increases the total deformation and shear stress gradually reduces and while increasing the wire diameter of the spring will result in the decreasing of fatigue life cycles. So, we must select the optimized wire diameter of the spring where the stresses generated are moderate and fatigue life cycles will not greatly reduce. So, the 11mm wire diameter of the spring is considered to be optimum.

V. FUTURE SCOPE

- Experimental Analysis for Helical coil compression spring to obtain the number of fatigue cycles at different wire diameter and different spring index is to be done.
- Analytical analysis and Numerical analysis for the Impact load Analysis for a Helical coil compression spring with different wire diameter and different spring index is to be done.
- By considering the Piston and cylinder at the centre of the Helical coil compression spring it is used as a Damper for the suspension system and by changing the piston fluid you can increase or decrease the damping, all the analytical and numerical analysis needs to be done.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Pangunuri Sai Sharath Chander Rao:

Conceptualization, Data curation, Investigation, Methodology, Writing – Original draft, Software, Validation.

Putti Srinivasa Rao:

Supervision, Resources, Writing – review and editing.

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