Experimental and Finite Element Analysis of Two Wheeler Suspension System using Stainless Steel Material

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Abstract - Helical spring is a mechanical device which is designed to carry, pull, or push loads. A study on the performance of helical spring used in the suspension of a two wheeler is undertaken in this work using stainless steel for the spring. The spring constants, load carrying capacity and the spring deflection are studied. It is found that this spring has the highest corrosive resistance and highest load carrying capacity. The results from the analysis of stainless steel material is obtained and compared with the carbon steel material for the two wheeler suspension system.

Key words - Helical spring, stainless steel, carbon steel, NX-CAD, ANSYS

I. INTRODUCTION

A suspension system is a protective arrangement of components which acts as shock absorbers like springs and dampers. It helps to ensure that your drive is safe and smooth by absorbing the energy from various road cracks and other impacts.

The modeling of suspension system is developed by NX CAD and carried out by ANSYS for the analysis process.

II. LITERATURE SURVEY

Na, J.; Huang, Y.Wu, X.Liu, Y.-J.; Li, Y.; Li, G. 2021, [1] Active Suspension Control of Quarter-Car System with Experimental Validation. Demonstrate that this control can obtain a superior performance and has better computational efficiency over several other control methods.

M. Stanco and M. Kowalczyk, 2022, [2] Analysis of experimental results regarding the selection of spring elements in the front suspension of a four-axle truck, Estimate the difference in the deflection of the springs of trucks while driving in tough conditions, on uneven, bumpy roads.

T. A. Nguyen, 2021, [3] Advance the efficiency of an active suspension system by the sliding mode control algorithm with five state variables, The SMC (Sliding Mode Control) algorithm is proposed to control the operation of the active suspension system. To optimize this algorithm, five state variables were considered.

M Gzal. 2017, [4] Analytical experimental and finite element analysis of elliptical cross-section helical spring with small helix angle under static load. Aims in determining the stress distribution in elliptical cross-section helical springs with small helix angle (less than 10°, often termed as close-coiled springs) considering the effect of wire curvature, subjected to axial static load.

Dr.Syed Ahamed1, [5] Shilpa P, Roshan J, 2019, A Literature Review On Aluminium-6061 Metal the individual and hybrid composites are discussed by aluminium alloy and different reinforcement material.

III. SOFTWARE (NXCAD AND ANSYS WORKBENCH):

NX, formerly known as "Unigraphics", is an advanced high-end CAD/CAM/CAE, which has been owned since 2007 by Siemens Digital Industries Software.

Unigraphics SDRC I-DEAS began an effort to integrate aspects of both software packages into a single product which became Unigraphics NX or NX-CAD.

ANSYS is a general-purpose, finite-element modeling package for numerically solving a wide variety of mechanical problems. These problems include static/dynamic, structural analysis, heat transfer, and fluid problems, as well as acoustic and electromagnetic problems. There are two methods to use ANSYS.

IV. DESIGN OF TWO WHEELER SUSPENSION ON NXCAD:

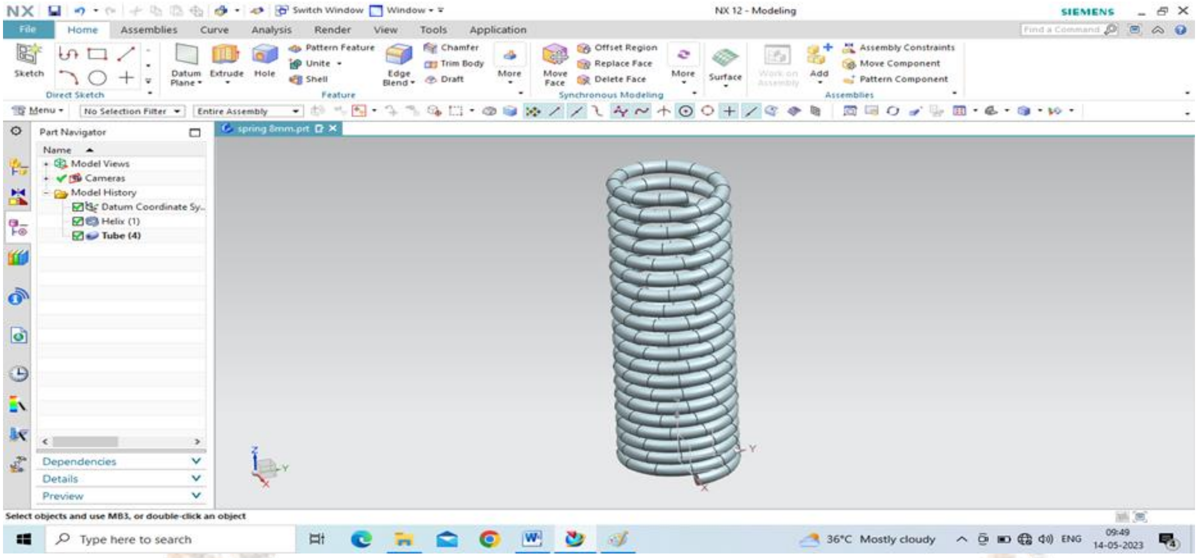

Fig-1: Design of helical spring

V. MATERIALS USED FOR ANALYSIS

Stainless steel AISI 304

Young's Modulus	200 GPa
Density	8000 kg/m3
Poison's Ratio	0.3
Elongation	55%

Carbon steel

Young's Modulus	190 GPa
Density	7850 kg/m3
Poison's Ratio	0.3
Elongation	45%

VI. ANALYSIS OF TWO WHEELER SUSPENSION USING ANSYS (STAINLESS STEEL):

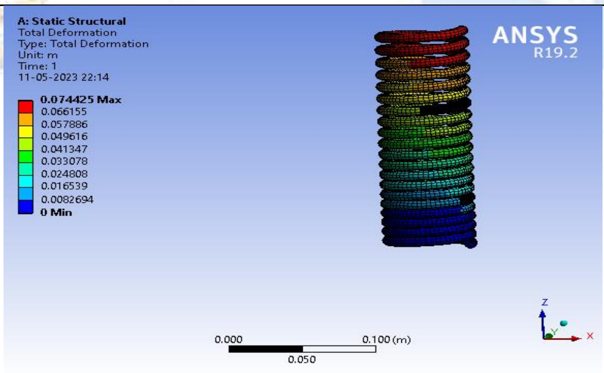

Fig-2: Total deflection

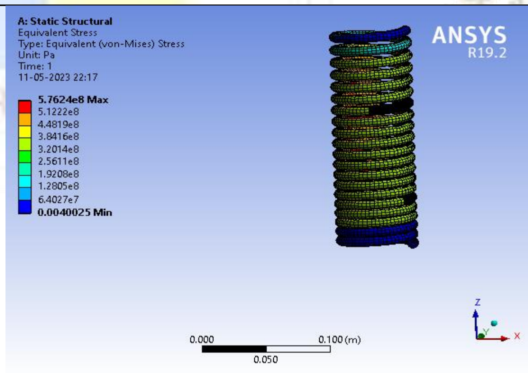

Fig-3:Equivalent stress

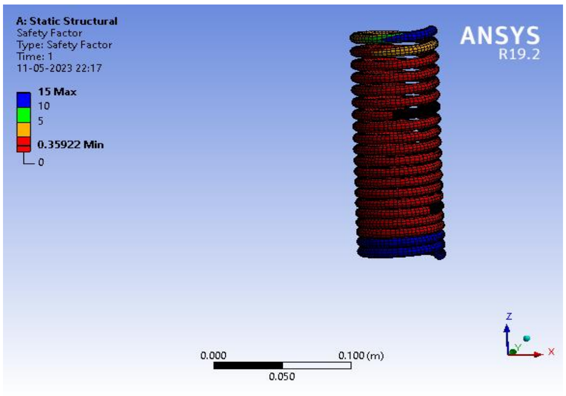

Fig-4:Factor of safety

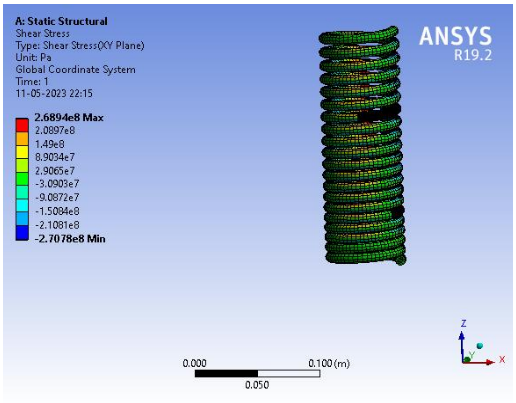

Fig-5:shear stress

VII. ANALYSIS OF TWO WHEELER SUSPENSION USING ANSYS (CARBON STEEL):

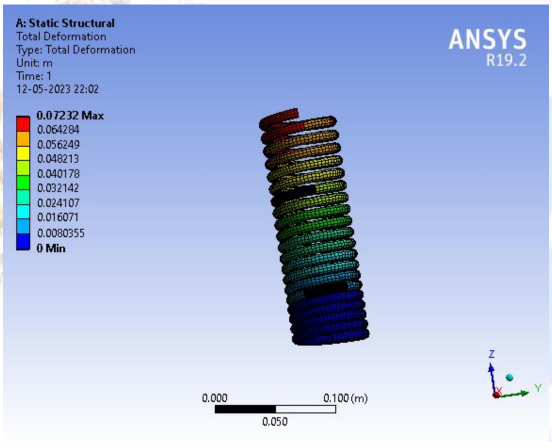

Fig-6: Total Deflection

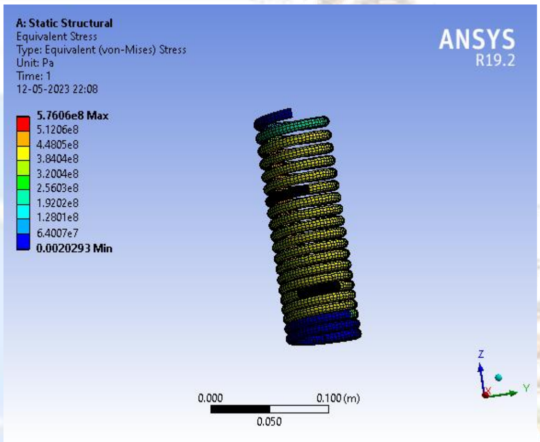

Fig7:Equivalent Stress

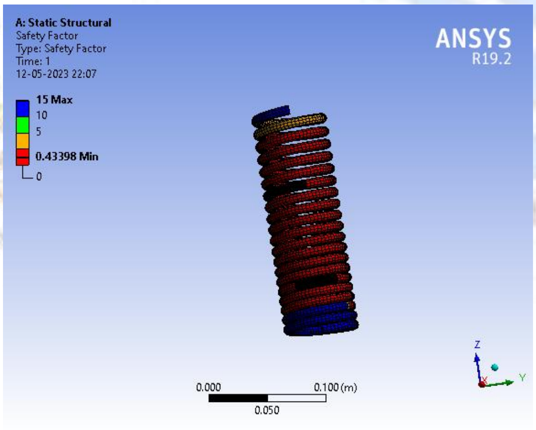

Fig8:Factor Of Safety

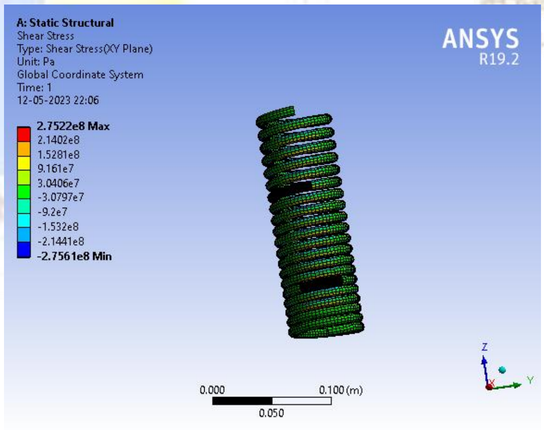

Fig9:Shear Stress

VIII. EXPERIMENTAL TESTING:

Fig no.10: Compression Testing

S.NO	LOAD		LOADING	UNLOADING
	KG	N	(mm)	(mm)
1	10	98.1	10	10
2	20	196.2	20	20
3	30	294.3	29.5	29.5
4	40	392.4	39.5	39.5
5	50	490.5	49.5	49.5
6	60	588.6	60	60
7	70	686.7	69	69
8	80	784.8	80	80
9	90	882.9	89	89
10	100	981	100	100

IX. THEORETICAL CALCULATION:

DIMENSIONAL DETAILS:

DESIGN DATA :(FOR STAINLESS STEEL)

1) Wire diameter (d) = 8mm
2) Coil outer diameter (D_O) = 68mm
3) Coil inner diameter (D_I) = 52mm
4) Free length of coil (L) = 240mm
5) Compressed length of coil (l) = 180mm
6) Load (P) = 900N
7) No of coils = 16

X. FORMULAE USED:

Formulae are taken from PSG Design Data Book:

1. Stiffness = Load/Deflection
2. Mean Coil Diameter(D) = $(D_I+D_O)/2$
3. Deflection(Y) = Free Length-Compressed Length
4. Number Of Coils(N) = $yGd^4/8pd^3$
5. Spring Index (C) = D/d
6. Wahl's Stress Factor(k) = (4c-1)/(4c-4)+(0.615/C)
7. Spring Constant (K) = $D4g/8nd^3$
8. Shear Modulus(G) = $k8nd^3/D^4$
9. Maximum Shear Stress (τ) = $k8pd/\pi d^3$
10. Factor Of Safety = Ultimate Stress/Working Stress

XI. CALCULATION FOR STAINLESS STEEL:

1) Deflection(Y)= = $n8PD^3/Gd^4$
= $16*8*900*60^3/0.8*10^5*8^4$
= 84mm

1. Stiffness = Load/deflection
= 900/60
= 15N/mm

2. Mean diameter = $(D_I+D_O)/2$
= (68+52)/2
= 60mm

3. Spring Index(C) = D/d
= 60/8
= 7

4. Wahl's stress factor(k) = ((4*7)-1/4*7-4)+(0.615/7))
= $1.201N/mm^2$

5. Maximum shear stress = $(1.201*8*900*60)/(3.14*8^3)$
= $340N/mm^2$

6. Factor of safety = 660/325
= 2.03

XII. CALCULATION OF CARBON STEEL:

1. Deflection(y) = $n8PD^3/Gd^4$
= $16*8*900*60^3/0.7*10^5*8^4$
= 75mm

2. Stiffness = Load/deflection
= 900/60
= 15N/mm

3. Mean diameter = $(D_I+D_O)/2$
= (68+52)/2
= 60mm

4. Spring index(c) = D/d
= 60/8
= 8

5. Wahl's stress factor(k) = ((4*8)-1/4*8-4)+(0.615/8))
= $1.25N/mm^2$

6. Maximum shear stress = $1.25*8*900*60/3.14*8^3$
= $298N/mm^2$

7. Factor of safety = 589/325=1.8

XIII. RESULT SUMMARY:

S.NO	MATERIALS	THEORETICAL			ANSYS		
		Total Deflection (mm)	Shear stress N/mm^2	FOS	Total Deflection (mm)	Shear stress N/mm^2	FOS (Avg)
1	Carbon steel	75	298	1.8	72	274	2.13
2	Stainless steel AISI304	84	340	2.0	74	270	2.9

XIV. CONCLUSION:

From this work the result shows both materials having more or less equal deflection and the stainless steel material convincing factor of safety which shows that the system can absorb more loads and has higher strength for above specified loading conditions. Finally, we conclude that the Suspension System with stainless steel material is best suited and has good factor of safety and high corrosive resistance when compared to the carbon steel material.

XV. REFERENCE:

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Dr.P.Parandaman presently working as Professor of Mechanical Engineering in Dhirajlal Gandhi College of Technology, Salem. He has more than 25 years of experience in Teaching as well as in Industry. He received honorary Doctorate for “Experimental studies on Mechanical Properties and Drilling behavior of Natural fiber reinforced Hybrid Composite Materials” from Anna University, Chennai. He has completed - Master of Engineering with Computer Aided Design from Government college of Engineering, Salem and Bachelors of Engineering in Mechanical Engineering from Government college of Technology, Coimbatore. Tamilnadu, India.

Areas of Interest: Design of Machine Elements, Finite Element Analysis, Manufacturing, Materials, Industrial Automation, Innovative ideas etc,.