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Analysis Of Helical Compression Spring For Two Wheeler Automotive Rear Suspension

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Abstract: *The present work is carried out on modeling, analysis of suspension spring is to replace the existed steel helical spring used in popular two wheeler vehicle. The stress and deflections of the helical spring is going to be reduced by using the new material. The comparative study is carried out between existed spring and new material spring. Static analysis determines the stress and deflections of the helical compression spring in analytical as well as finite element analysis. The structural reliability of the spring must therefore be ensured. So for this purpose the static stress analysis using finite element method has been done in order to find out the detailed stress distribution of the spring. The analytical & finite element analysis carried out by changing cross sectional area of helical spring from circular to rectangular to check its feasibility. Finite element analysis methods (FEA) are the methods of finding approximate solutions to a physical problem defined in a finite region or domain. FEA is a mathematical tool for solving engineering problems. In this the finite element analysis values are compared to the analytical values. A typical two wheeler suspension spring is chosen for study. The modeling of spring is developed on pro/E 5.0 analysis is carried out on Ansys 14.*

Kew Words: *Helical spring, Finite Element Analysis, New Material, Static Analysis*

I. Introduction

A spring is defined as an elastic body, whose function is to distort when loaded and to recover its original shape when the load is removed. It is an elastic object used to store mechanical energy. Springs are usually made out of spring steel. Small springs can be wound from pre-hardened stock, while larger ones are made from annealed steel and hardened after fabrication. Some non-ferrous metals are also used including phosphor bronze and titanium for parts requiring corrosion resistance and beryllium copper for springs carrying electrical current (because of its low electrical resistance). When a spring is compressed or stretched, the force it exerts is proportional to its change in length.

Helical springs are simple forms of springs, commonly used for the suspension system in wheeled vehicles. Vehicle suspension system is made out of springs that have basic role in power transfer, vehicle motion and driving. Therefore, springs performance optimization plays important role in improvement of car dynamic. The automobile industry tends to improve the comfort of user and reach appropriate balance of comfort riding qualities and economy.

The helical springs are said to be closely coiled when the spring wire is coiled so close that the plane containing each turn is nearly at right angles to the axis of the helix and the wire is subjected to torsion. In other words, in a closely coiled helical spring, the helix angle is very small; it is usually less than 10 degree. The major stresses produced in helical springs are shear stresses due to twisting. The load applied is parallel to or along the axis of the spring. In open coiled helical springs, the spring wire is coiled in such a way that there is a gap between the two consecutive turns, as a result of which the helix angle is large. Helical springs are generally used in two different applications. The first is the role of compression spring which offers resistance to forces moving two components towards each other. Typical applications are car suspension and matters spring. Compression springs typically have their ends end and allowing for easy mounting. The second common use for helical spring is as a tensioning element. Springs used in this role resists forces moving in two objects away from each other. A couple of common tension spring applications include spring scales and automatic door closers.

High-carbon spring steels are the most commonly used of all springs materials. This material is preferred to others because they are least expensive, readily available, easily worked, and most popular. These materials are not satisfactory for high or low temperatures or for shock or impact loading. Also this is the general purpose spring steels and should only be used where life accuracy and deflection are not too important.
Vanadium- Chrome steel is an alloy steel which states that it contains one or more elements other than carbon in sufficient proportion to modify or improve substantially and positively some of its useful properties. They are most popular alloy spring for improved stress, fatigue, long endurance life conditions as compared to high carbon steel materials. Both chromium and vanadium increase the harden ability of steel. Important synergistic effects, not yet fully defined, can also occur when combinations are used in place of single elements. This is best

suited for impact and shock loading conditions.

Automotive springs have to face very high working stresses. The structural reliability of the spring must therefore be ensured. So for this purpose the static stress analysis using finite element method has been done in order to find out the detailed stress distribution of the spring [2]. To extend life in place of present spring co-axial (series) spring is analyzed. Also factors affecting fatigue life of this compression spring are stated [3].

Alternatively, design can involve selecting a new material having a better combination of characteristics for a specific application; choice of material cannot be made without consideration of necessary manufacturing processes (i.e., forming, welding, etc.), which also rely on material properties. Or, finally, design might mean developing a process for producing a material having better properties [4]. In order to predict probable failure positions in helical compression springs, used in fuel injection system, along the length of the spring at inner side, finite element analyses was carried out, using ABAQUS 6.10[5]. Reduction in weight is a need of automobile industry. Thus the springs are to be designed for higher stresses with small dimensions. This requires critical design of coil springs. This leads to critical material and manufacturing processes. Decarburization that was not a major issue in the past now becomes essential, to have better spring design [6]. Combination of springs with steel and composite material i.e. Glass fiber epoxy resin is to be used in place of conventional spring steel [7]. The vehicle handling becomes very difficult and leads to uncomfortable ride when bouncing is allowed uncontrolled. Hence, the designing of spring in a suspension system is very crucial. The analysis is done by considering bike mass, loads, and no of persons seated on bike. Comparison is done by varying the wire diameter of the coil spring to verify the best dimension for the spring in shock absorber. Modeling and Analysis is done using Pro/ENGINEER and ANSYS respectively [8]. The design and modification of the suspension system and analyzing that could it be replaced one heavy duty spring in the place of double springs [9]. As per reverse engineering is concerned a front suspension system of a automobile is taken and complete drawing/measurement is taken approximately and modeled in CREO design software .Further to analyze the model created it is meshed in ANSYS and analysis of coil spring is done by assignment of materials like structural , stainless and chromium vanadium steel .Overall intention of the thesis is to understand the concepts of reverse engineering , designing and analysis with knowledge of engineering materials by using suspension model [10].

II. Analytical Design Of Helical Coil Spring

Hard Carbon Steel:

1 Nominal Chemical Property:

Carbon	Manganese(Mn)	Phosphorus(P)	Sulphur(S)	Silicon(Si)
0.48 – 0.85	0.3 – 1.30	≤ 0.04	≤ 0.05	0.15- 0.30

2 Specifications:

Do	-	Upper Outer dia. =	45mm
Di	-	Lower outer dia. =	60mm
		Height of spring =	240mm
d	-	Dia. of spring wire =	6mm
		Pitch at start =	8mm
		Pitch at end =	16mm
		Pitch at quarter middle =	13mm

3 Nominal Mechanical Properties:

Young's Modulus - 206000Mpa
Modulus of Rigidity- 85000Mpa
Density 7800 kg/m3
Poisson's ratio - 0.3

Chrome Vanadium Steel:

1.Nominal Chemical Properties

Carbon (c)	Manganese (Mn)	Phosphorus (P)	Sulphur (S)	Silicon (Si)	Chromium (Cr)	Other (Ni, Vetc)
0.48 -0.53	0.70 – 0.90	≤ 0.04	≤ 0.04	0.15 – 0.35	0.8 -1.10	≤ 0.15

2.Nominal Mechanical Properties :

Young's Modulus	=	207000 *Mpa*
Modulus of Rigidity	=	87500 *Mpa*
Density	=	7800 *kg /m3*
Poisons ratio	=	0.28

3.Design calculations:

i) Spring index C = $\frac{D}{d}$; ii) Wahl's Stress Factor K = $\frac{4c-1}{4c-4} + \frac{0.615}{c}$

ii) Maximum shear stress, $\tau = \frac{K \times 8FD}{\pi d3}$

III. Finite Element Analysis For Spring

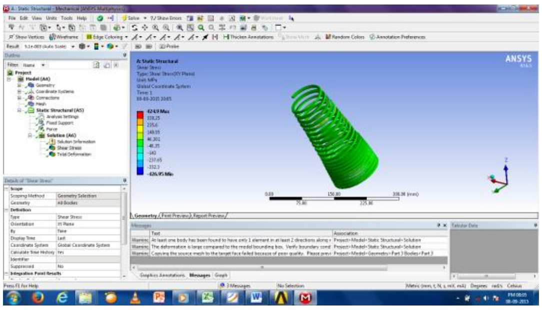
Finite Element Analysis is carried out by using CAE Software ANSYS Workbench.
Finite Element Analysis mainly consist of the following three stages, namely
1) Preprocessing stage
2) Processing stage
3) Post processing stage

Steps in Pre-processing stage

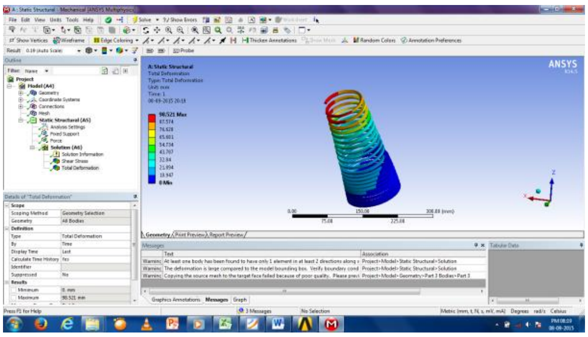
The CAD model from Pro-E CAD Software tool has been imported. Mesh the model which is nothing but creation of nodes and elements. The fine mesh model has been used which improves the accuracy of the solution and also provides accurate results at the end. Splitting up into no. of nodes & elements followed by application of loading and boundary conditions.

Hard carbon steel & chrome vanadium steel used for helical spring are analyzed for circular & rectangular c/s for shear stress & deflection at 55N, 65N, 75N, 85N, 95N.

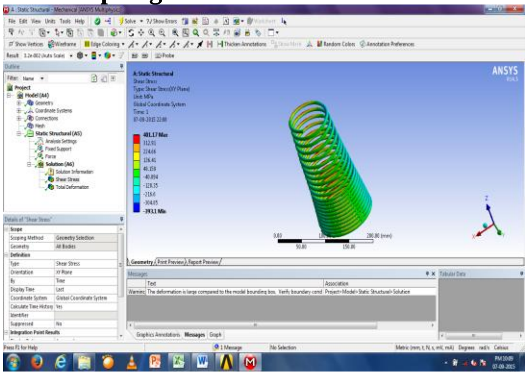
1) FEA for Chrome Vanadium Spring Steel with Rectangular Section for Shear Stress under 55N



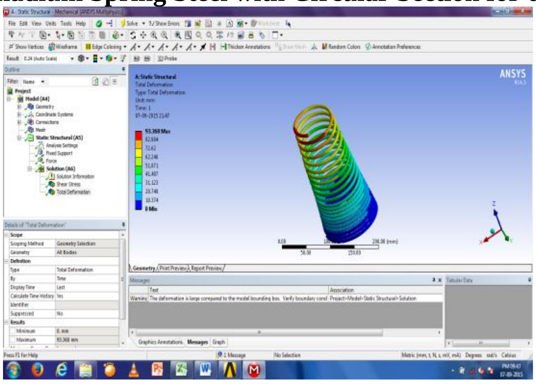
2) FEA for Chrome Vanadium Spring Steel with Rectangular Section for deformation under 55N.



3) FEA for Chrome Vanadium Spring Steel with Circular Section for Shear Stress under 55N



4) FEA for Chrome Vanadium Spring Steel with Circular Section for deformation under 55N.



IV. Result

Sr. No.	Load (N)	Analytical Result		ANSYS Result	
		ShearStress(mpa)	Deflection(mm)	ShearStress(mpa)	Deflection(mm)
1	55	389.71	90.2	403.34	96.265
2	65	460.2	106.6	473.11	115.52
3	75	531	123	545.06	134.77
4	85	601.8	139.4	614.83	146.32
5	95	672.6	155.8	686.77	165.58

Table above shows the ANALYTICAL values & ANSYS values for shear stress & deflection of hard carbon spring steel (circular c/s).

Sr. No.	Load (N)	Analytical Result		ANSYS Result	
		ShearStress(mpa)	Deflection(mm)	ShearStress(mpa)	Deflection(mm)
1	55	389.71	88	401.17	93.36
2	65	460.2	96	468.75	100.84
3	75	531	104	538.52	112.04
4	85	601.8	136	608.29	141.92
5	95	672.6	152	682.42	160.59

Table above shows the ANALYTICAL values & ANSYS values for shear stress & deflection of chrome vanadium spring steel (circular c/s).

Sr. No.	Load (N)	Analytical Result		ANSYS Result	
		ShearStress(mpa)	Deflection(mm)	ShearStress(mpa)	Deflection(mm)
	55	389.71	90.2	436.09	105.65
	65	460.2	106.6	496.66	120.44
	75	531	123	581.45	139.46
	85	601.8	139.4	642.02	150.03
	95	672.6	155.8	709.86	169.04

Table above shows the ANALYTICAL values & ANSYS values for shear stress & deflection of hard carbon spring steel (Rectangular c/s).

Sr. No.	Load (N)	Analytical Result		ANSYS Result	
		ShearStress(mpa)	Deflection(mm)	ShearStress(mpa)	Deflection(mm)
1	55	389.71	88	424.9	98.52
2	65	460.2	96	488.03	106.91
3	75	531	104	570.59	119.48
4	85	601.8	136	633.72	146.73
5	95	672.6	152	704.13	163.5

Table above shows the ANALYTICAL values & ANSYS values for shear stress & deflection of chrome vanadium spring steel (Rectangular c/s).

V. Conclusion

The helical coil spring of hard carbon steel & chrome vanadium spring steel for circular & rectangular cross sections are studied using FEA analysis. The shear stress & deflection values are obtained. The values of shear stress & deflection of hard carbon steel & chrome vanadium spring steel for circular cross sections as well as rectangular cross sections are compared. The FEA results proves that even though the stresses are almost equal, but the deflection of suspension spring is more when comparative to the hard carbon steel and it will works efficiently with less maintenance.

The above result shows that the Chrome Vanadium is best replacement of hard carbon steel. The cost of Chrome vanadium steel material is cheaper in India and international markets compare to hard carbon steel.

As a consequence, the research also efforts on changing the cross section of helical compression spring from circular to rectangular. But the structural reliability of helical compression spring ensured for circular cross section.

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