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Analysis and Simulation of Helical Spring with Carbon steel material for Automotive vehicle

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A B S T R A C T

Helical spring assumes a significant job in numerous applications, for example, machines, and vehicles. At the point when a helical spring is under a static load. The normal static model for helical spring is the Wahl's factor equation, which consider all design parameters, for example, wire diameter, helix radius, spring radius and pitch angle are constant. In this research work, finite element analysis method is used to analysis of the stress and displacement under the different load condition with carbon steel material. In these process of FEM, the design parameters include pitch angle, wire diameter and helix radius are included. Finite element analysis and simulation were performed with Ansys software.

Keywords: Helical Spring, Carbon steel, Displacement, Stress, FEM

1. INTRODUCTION

One of the most important system in a vehicle is the suspension system. The main aim of any suspension system is to maximize the friction between the earth surface and the tires to offer the stability steering.

Vehicle suspension system contains of three elements which are spring, wishbones and the shock absorber. The application of above three elements are to filter and transmit forces exerted between the vehicle body and the road. The spring is one of the most important system as it carries the body mass of the vehicle form rough and zigzag road surface [1]. This contributes to provide a comfort driving. Spring is an elastic component, whose function is to distort when loaded and again come to its original shape when the load is removed.

To control the energy, absorb or provide cushion due to shock or vibration as in car spring, railway buffers, air craft landing gear, and shock absorbers. Also it uses to apply the forces as in clutches, breaks and spring loaded valves. Spring also uses to store the energy as in watches. Based on the spring shape and application, there is different type of spring.

Among all above types of springs, leaf springs and helical springs are mostly used in automobile suspension system. The structure of helical springs are made up of a wire coiled in the form of helix. The cross-section of wire from which the spring is made may be circular, square or rectangular. The two forms of helical springs are compression helical spring and tension helical spring. Only the compression springs will be of interest in this study. A typical 3D model of compression coil spring can be seen in Figure 1

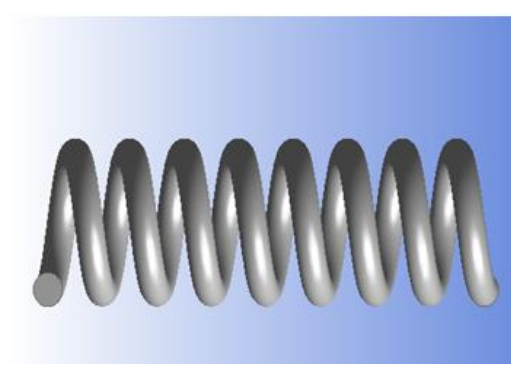


Fig 1 Compression Helical Coil Spring

According to Wahl, [4] "A spring may be defined as an elastic body whose primary function is to deflect or distort under loading condition and recovers its original shape when force is released after being distorted. Along with this definitions of the helical spring, the body chassis of the automobile car and even the shoes that we wear also will be considered as a spring. S. Kamiya, et.al presented the FEA model on the load spring to determine the effects of parameters such as number of free coils and slenderness ratio to the spring characteristics [5]. They also explained the methods of the setting preparation of spring and the procedure of tilting angle of spring seat for reducing side force. They developed, a Finite element model for the side load spring and also study the effects of parameters such as spring end coil angles and seat angles on the reaction force line of the side load spring. They introduce the new design with the combination of Finite element Analysis and mechanical dynamics. However, the design procedure was not signified fully, and some developments still need to be deliberated for the design procedure [6]. P Singh et al. they had developed the 3D finite element model of helical spring by using the Ansys software. They applied the different type of material to develop the helical spring [7]. P. Ghate et al. analyzed the failure of A Freight Locomotive helical spring by redesigning to improve the durability and ride index in this the composite suspension system can sustain the loads in under normal operation conditions and maintains the ride index but the failure occurs during cornering and hunting speeds to avoid this the study of dynamic behavior of a composite spring is analyzed [8] K Pavan Kumar et.al. deliberated about the static analysis of primary suspension system, they supported out on modeling helical spring in Pro/E and analysis in ANSYS of primary suspension spring with two materials Chrome Vanadium is a existing material and 60Si2MnA steel is a new material, the traditional steel helical spring 60Si2MnA is demonstrated as best material for helical spring by decrease of diversion and by and large pressure [8]. The objective of this present work is to determine the safe load of the vehicle suspension helical spring with different type of materials and attain the optimum design. In this project work a Catia software and Ansys software has been used to create and analysis of the helical spring design.

2. PROCEDURE OF SIMULATION

2. Procedure
2.1 Material selection
The high carbon steel has been selected based on the literature review. This material is generally used in the automotive industries for the helical spring. Table 1 show chemical composition of the high carbon steel. Table 2 shows the Mechanical properties of High-carbon steel.

Table. 1 shows the chemical composition of the high carbon steel

Element	C	Fe	Mn	P	Si	S	Cr	Mo	Ni
% of composition	0.61	98.81	0.75	0.013	0.25	0.0107	0.108	0.0778	0.013

Table 2 Mechanical properties of High-carbon steel

Properties	Density	Elastic Modulus	Poisson's Ratio	Shear Modulus
Values	7850 kg/m^3	2.1 × 10^{11} Pa	0.295	7.6 × 10^{11} Pa

2.2 Spring design specification [12]
D = 46.0 mm
d = 8.0 mm
n = 10 mm
nt = 12 mm
Lf = 195 mm
Ls = 96 mm
W = 1640 N

Numeric calculation to determine the values

Spring index: C = D/d = 46/8 = 5.75

Modeling and Simulation of Helical Spring
2.3 3D model creation
The CATIA V5 software used to create the helical spring. Catia software is capable to develop the different type of geometry, assembly, sheet metal work and so on with using different type of module. To develop the 3D model of helical spring, part design assembly has been used.
3.2 Simulation of helical spring
The Finite Element Method (FEM) provide a platform to achieve the approximate solution of the real word problems. Finite element method is a numerical approach for determined the approximate solution of the engineering & sciences problems
In the FEM, a complex region defining a continuum is discretized into simple geometric shapes termed elements. The properties and the governing relationships are assumed over these elements and expressed mathematically in terms of unknown values at specific points in the elements called nodes.

2.4 Modeling of helical spring

The helical spring performance will be observed by selecting the different materials properties to determine the optimum stresses and the result to identify which one material is more suitable. Model of the spring will be first created by using CATIA V5. The parameters to draw helical spring has been taken from the Table. Solid model of helical spring as shown in figure 2 .

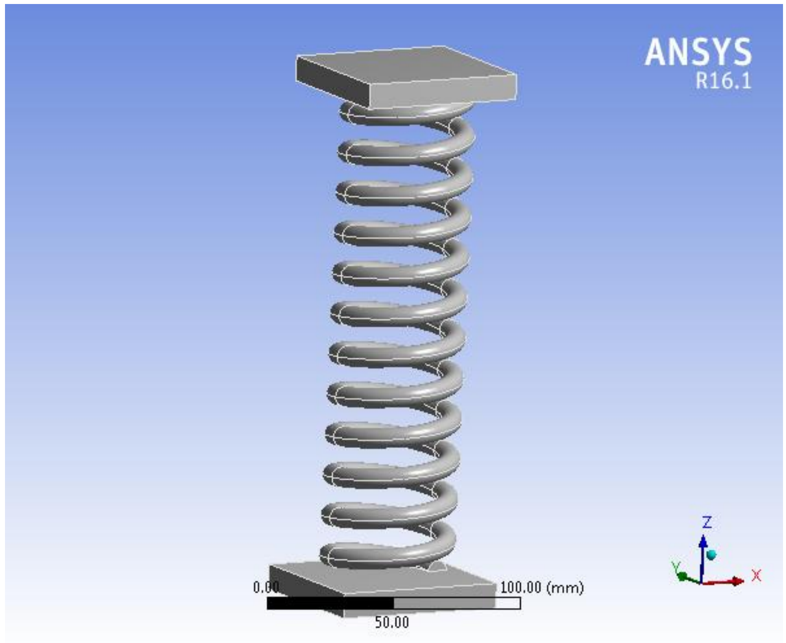


Fig. 23D model of compression helical spring

2.5 Mesh

Meshing play very important role in the finite element analysis. Meshing divide the one element in to the finite number of element. Generally, as per requirement researcher takes the fine, medium and coarse mesh size. Simulation time is directly proportional to the Mesh size. Figure 3 shown the mesh helical spring.

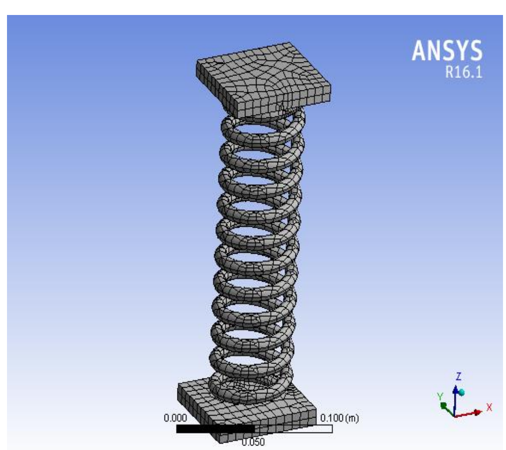


Fig. 3 Meshing with Hexahedral Elements

3. RESULTS AND DISCUSSION

This section has static analysis of carbon steel sheet. In this study, 26290 nodes and 8753 element has been selected in meshing zone. The node is the junction of the elements. This numbers are clearly indicate the density of the meshing.

3.1 Static Analysis of high carbon steel

The static analysis of compression helical spring has been investigated with respect to high carbon steel properties and boundary conditions as mentioned in material specifications Table 1 & 2. The one end of the helical spring has been fixed supported. The force of 1640 N has applied on the other end. The nonlinear effect and thermal strain effect both are consider in the static analysis. The displacements of the compression helical spring has been recorded in all three possible direction such as in x- direction, y-direction, z-direction and also find out the total displacement. The Figure 4 shown the total deformation of carbon steel helical spring. The maximum deformation 51.61 mm has been observed. Figure 5 to Figure 7 depicts the directional deformation in respect to X direction, Y direction and Z direction. The 2.26 mm, X direction deformation has been observed as depicts in Figure 5. The 10.51 mm, Y direction deformation has been observed as depicts in Figure 6. The 0.035 mm, Z direction deformation has been observed as depicts in Figure 7. In the Y direction deformation is more as compare to X direction and Z direction because of the force is applied along the Y direction. 543.06 MPa shear stress has been observed in the Fig 8. Fig 9 shows the stress intensity in helical spring. This analysis also shows Von misses stress, Von misses strain shown in Fig 4 &11.

Table 3 depicts the displacement value of helical spring under load with material of carbon steel and stainless steel. Table 4 depicts the stress and strain value of helical spring under load with material of carbon steel and stainless steel

Table 3 Displacement of helical spring

Type of Material	X Displacement(mm)	Y Displacement (mm)	Z Displacement (mm)	Total Displacement (mm)
Carbon steel	2.266	10.516	0.0359	51.61

Table 4 Stress and strain of helical spring

Type of Material	Shear Stress (MPa)	Stress intensity (MPa)	Equivalent stress (MPa)	Equivalent strain
Carbon steel	543.06	1204.3	1095.1	0.0055

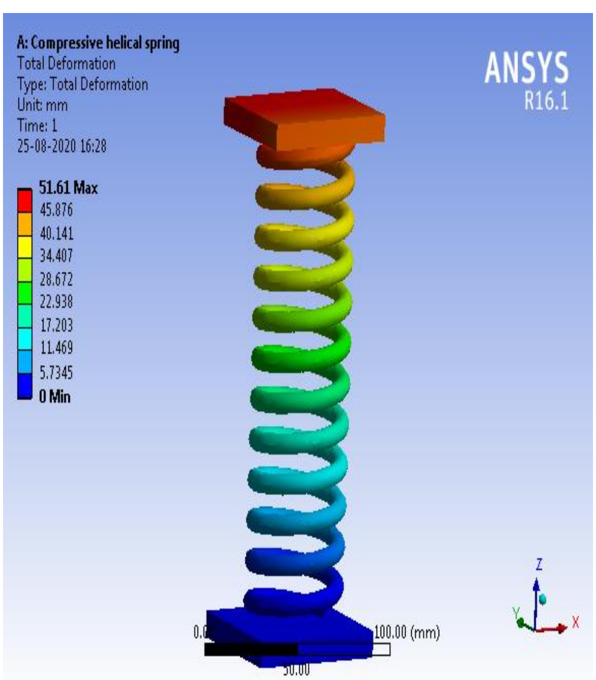
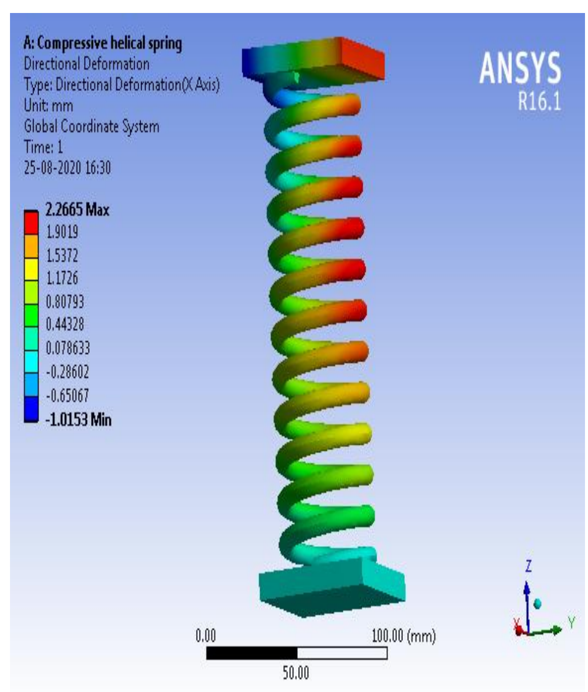


Fig. 4 Total deformation of helical spring of carbon steel



Fig, 5X direction deformation of helical spring of carbon steel

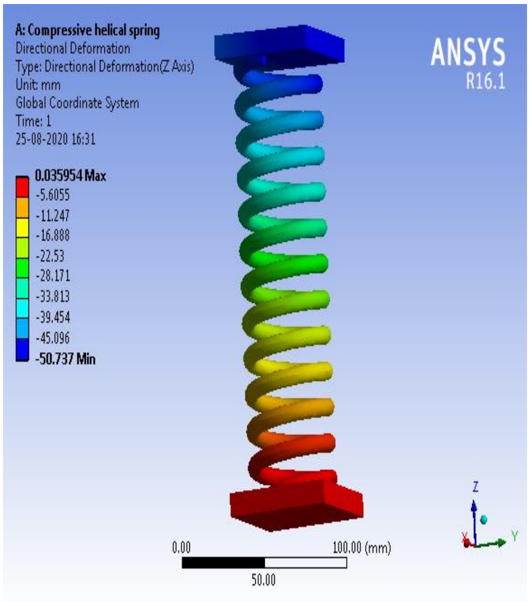


Fig 6 Y direction deformation of helical spring of carbon steel

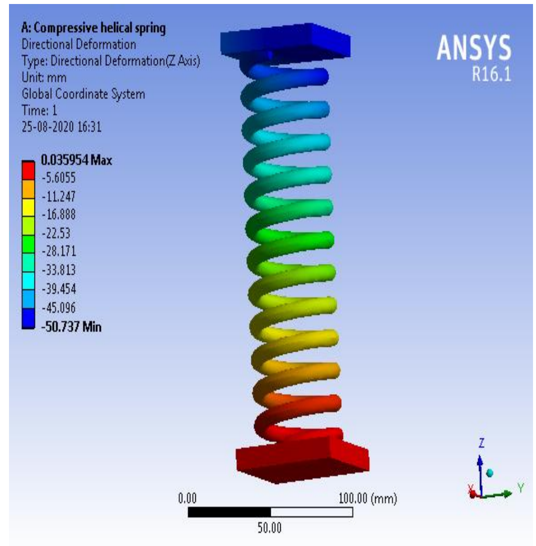


Fig 7Z direction deformation of helical spring of carbon steel

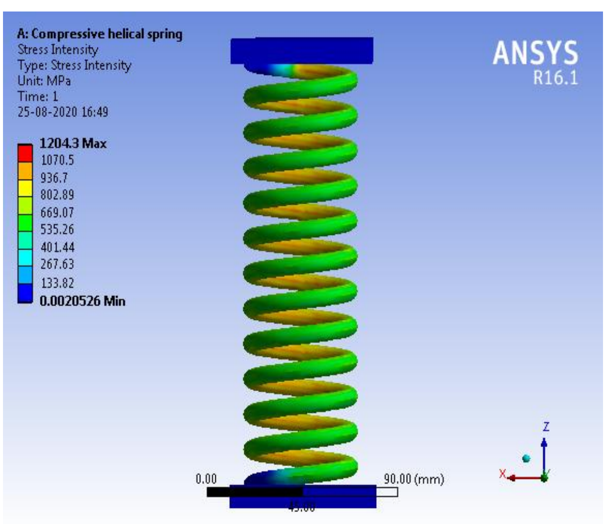


Fig.8 Shear Stress in helical spring of carbon steel

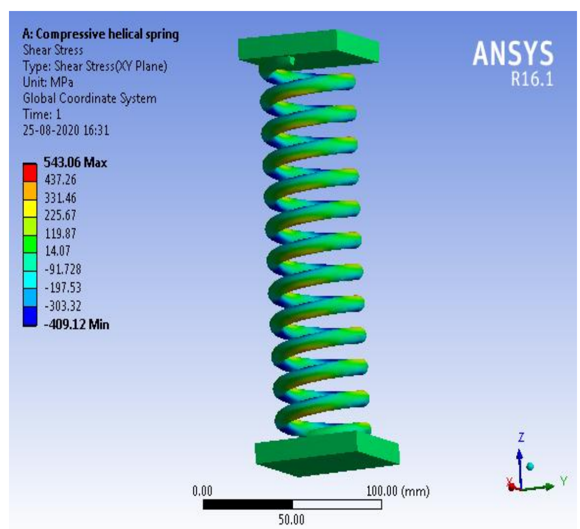


Fig.9 Shear intensity in helical spring of carbon steel

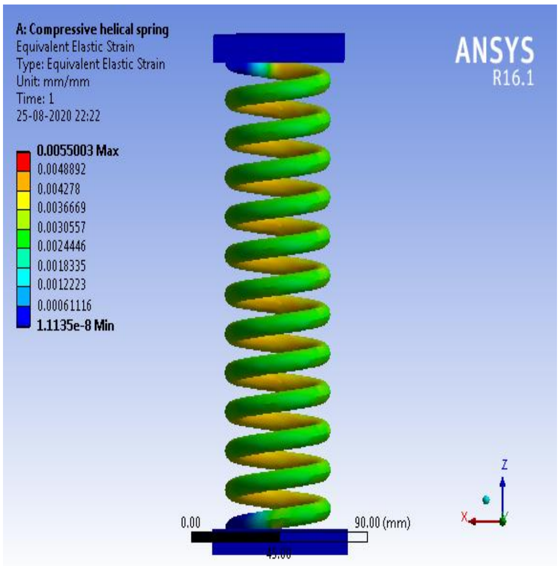


Fig. 10 equivalent stress in helical spring of carbon steel

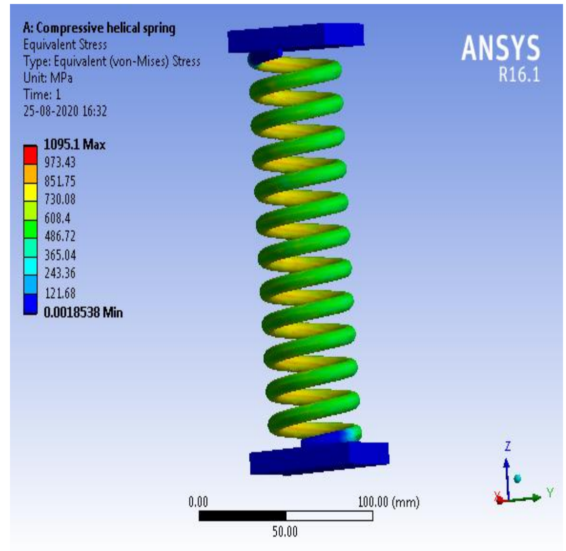


Fig. 11 Shear Stress in helical spring of carbon steel

4. CONCLUSION

The present project work based on the optimum design investigation and analysis of a suspension compression helical spring for the automobile industries. The static analysis of spring, responses are stress and strain of helical spring has been analyzed under the required and expected load.

The simulation induced stress and strains values for the carbon steel is less compared to stainless steel and also it improve the fatigue life of helical spring.

The following conclusion has been drawn from the results analysis.

1. The equivalent stress (vonmises stress) induced carbon steel is 1095.1 MPa .
2. The equivalent strain (vonmises strains) induced in carbon steel is 0.0055
3. The stress intensity in carbon steel is 1204.3 MPa
4. The shear stress induced in carbon steel is 543.06 MPa

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