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Analysis and Simulation of Helical Spring with Stainless Steel Material for Automotive Vehicle

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A B S T R A C T

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. Helical spring undertakes a significant job in various 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 Stainless 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, Stainless steel, Displacement, Stress, FEM

1. INTRODUCTION

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. Flow chart of the suspension system and Classification of different type of spring can be seen in Figure 1& 2. The helical springs are also called closely coiled when the spring wire is coiled so near that the plan containing each turn is nearly at right angles to the axis of the helix and wire is subjected to torsion. In the open coiled helical springs, the spring wire is coiled in such a way that there is a gap between the two consecutive turns.

1.2 Material for helical springs

The material of the spring should have following properties as mentioned below High ductility

High resilience Creep resistant

Mainly helical spring material selection is largely depends upon the application such as serve service, Average service and light service [2].

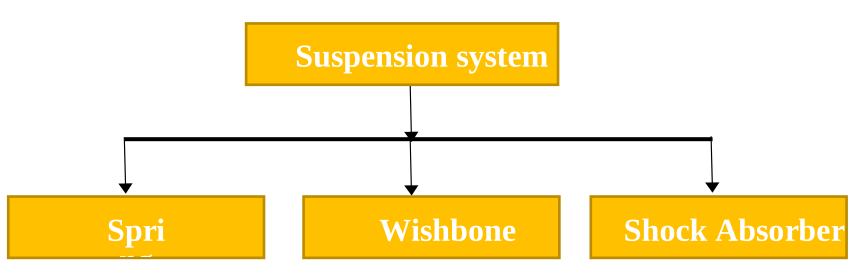

Fig. 1 Flow chart of the suspension system

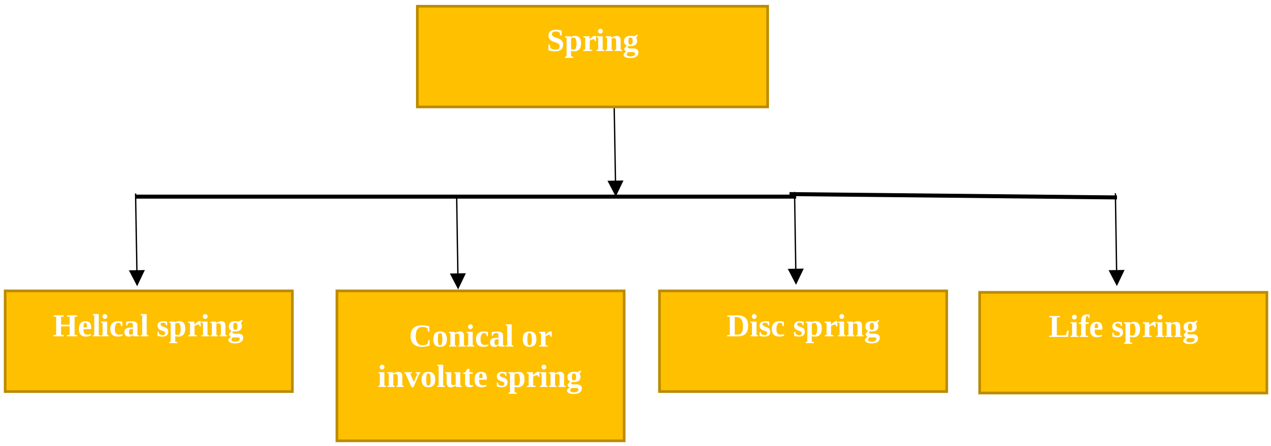

Fig.2 Classification of different type of spring

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. N.Lavanya et.al.They investigated the optimum design and analysis of a suspension spring for motor vehicle subjected to static analysis of helical spring. the work shows the strain and strain reaction of spring conduct will be seen under recommended or expected burdens and the initiated pressure and strains esteems for low carbon basic steel is less contrasted with chrome vanadium material additionally it improves the cyclic exhaustion of helical spring[12]. Y. Takao T. Takeaki and G. Mitsuo shown the formulate an design for optimal weight of helical spring for a controlled allowable shearing stress, number of active coils and coil's usual radius as a nonlinear integer software design problem and solve it directly by keeping the nonlinear constraint by using improved genetic algorithm. As a result, the number of decision (design) variables did not increase, the best cooperated solution is generated [13].

The objective of this present work is to determine the safe load of the vehicle suspension helical spring with stainless steel 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 Chemical Composition of StainlessSteel

Elements	Cr	V	Mn	C	Si	P
Composition (%)	18.00-20.00	0.18 approx	2.0	0.08	0.75	0.045

Table 2 Mechanical properties of StainlessSteel

Properties	Density	Elastic Modulus	Poisson's Ratio
Values	7860 kg/m3	E = 200 GPa	0.37

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 3 .

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 4 shown the mesh helical spring.

Table 3 Displacement of helical spring

Type of Material	X Displacement(mm)	Y Displacement (mm)	Z Displacement (mm)	Total Displacement (mm)
Stainless steel	2.40	11.003	0.0375	53.869

Table .4 Stress and strain of helical spring

Type of Material	Shear Stress (MPa)	Stress intensity (MPa)	Equivalent stress (MPa)	Equivalent strain
Stainless steel	546.29	1211.3	1102.3	0.0057

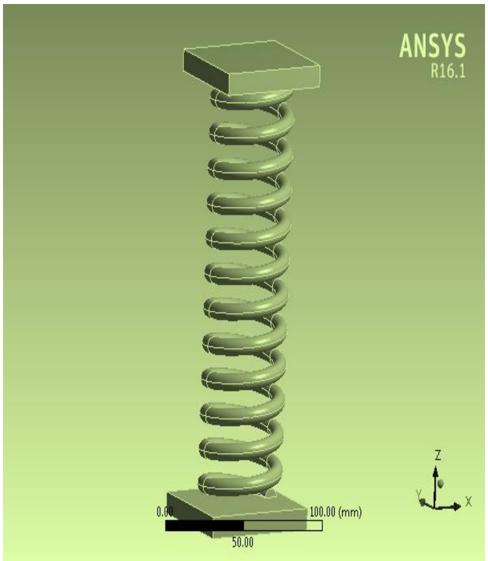

Fig. 33D model of compression helical spring

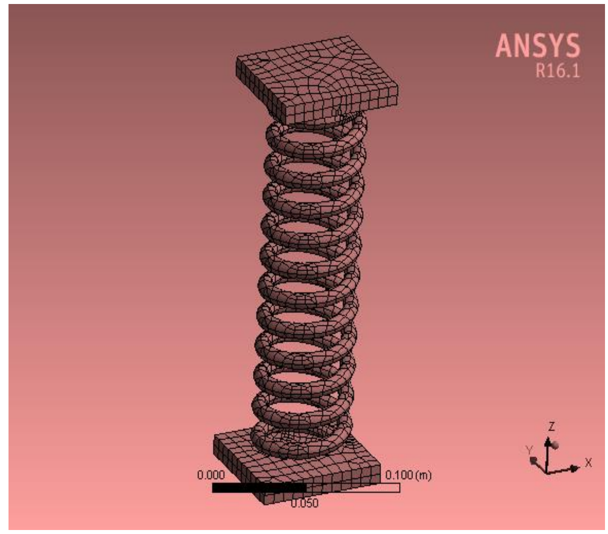

Fig. 4 Meshing with Hexahedral Elements

3. RESULTS AND DISCUSSION

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.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 th e elements. This numbers are clearly indicate the density of the meshing.

3.1 Static Analysis of Stainless Steel

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 analysis. The displacements in the helical spring in x- direction, y-direction, z-direction and also total displacement shown in figure.5 to Figure 8. This analysis also shows shear stress, stress intensity, Von misses stress, and vonmises strain are shown in Figure 9 to Figure 12

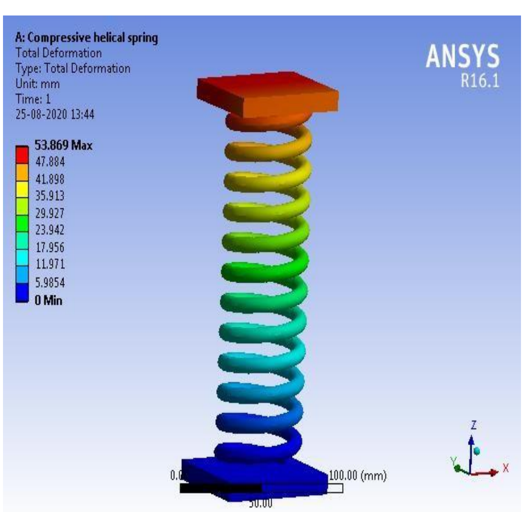

Fig. 5 Total deformation of helical spring of Stainless steel

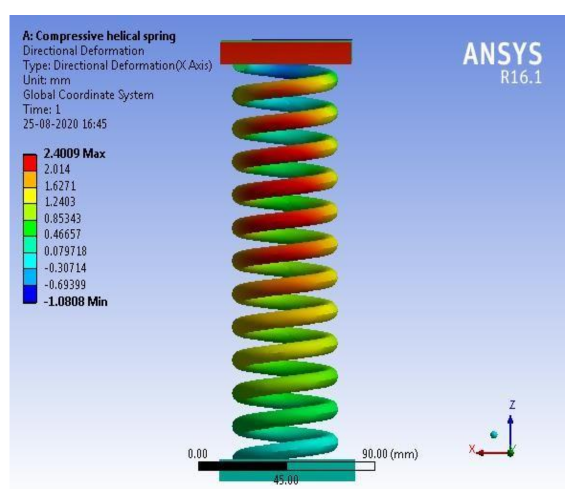

Fig 6 X direction deformation of helical spring of Stainless steel

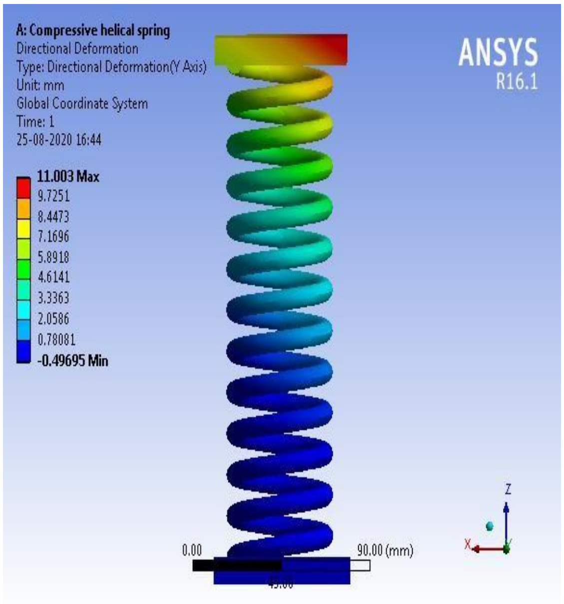

Fig 7Y direction deformation of helical spring of Stainless steel

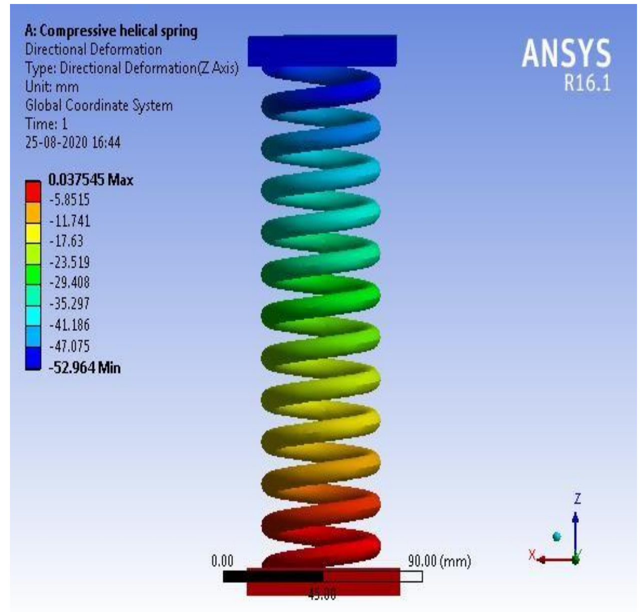

Fig 8Z direction deformation of helical spring of Stainless steel

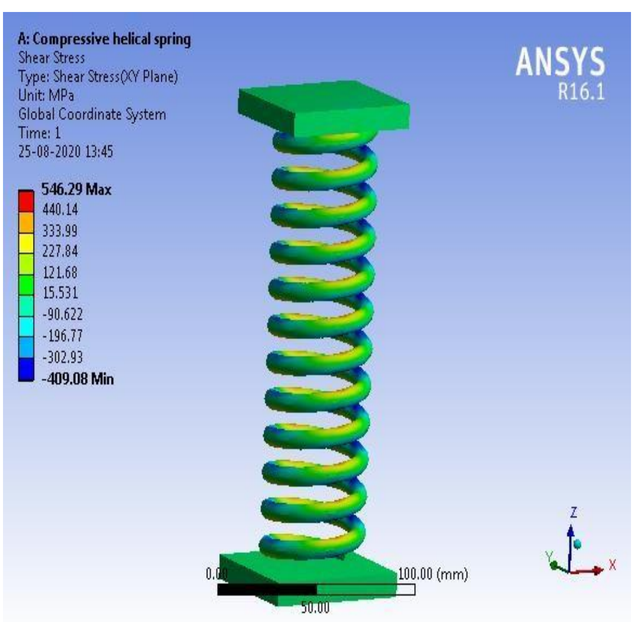

Fig.9 Shear Stress in helical spring of stainless steel

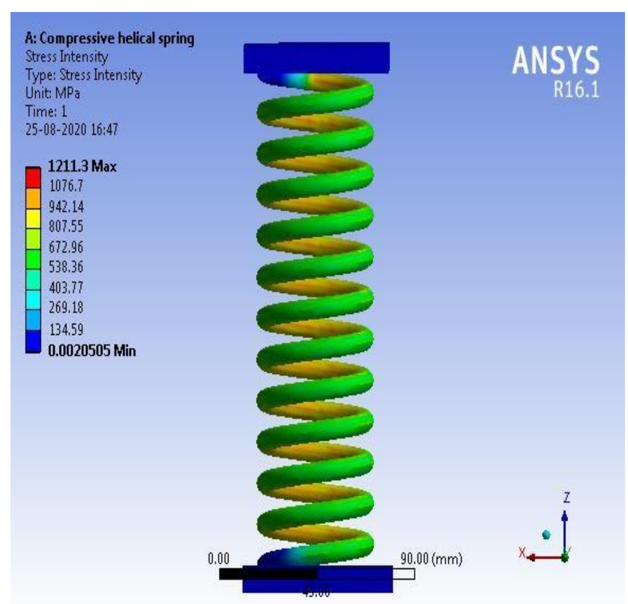

Fig.10 Shear intensity in helical spring of Stainless steel

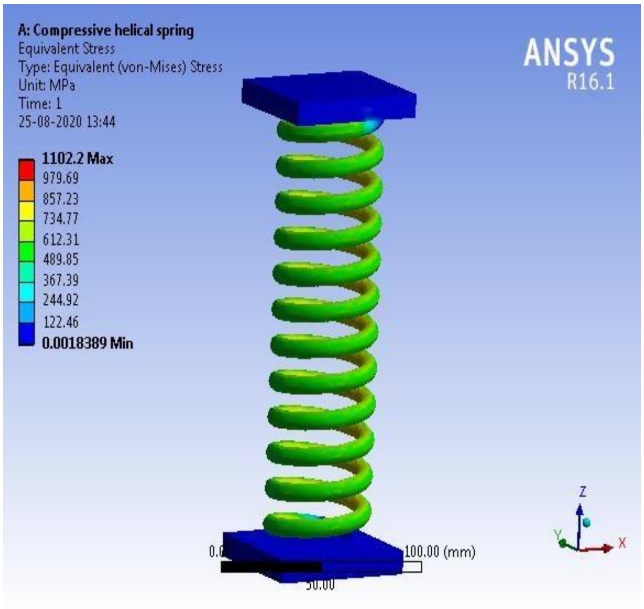

Fig. 11 equivalent stress in helical spring of Stainless steel

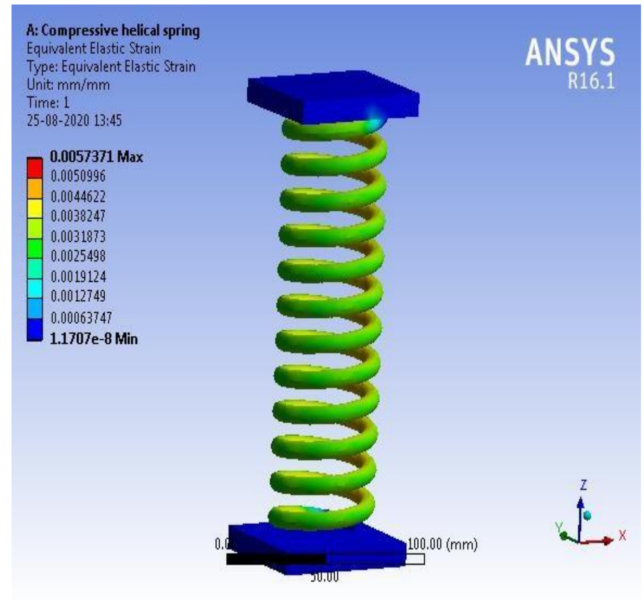

Fig. 12 Shear Stress in helical spring of stainless steel

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 for stainless steel is 1102 MPa and for.
2. The equivalent strain (vonmises strains) induced in stainless steel is 0.0057
3. The stress intensity in stainless steel is 1211.3 MPa.
4. The shear stress induced in stainless steel is 546.29.

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