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Design and Analysis of A Suspension Coil Spring For Automotive Vehicle

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ABSTRACT :
The suspension system is used to observe the vibrations from shock loads due to irregularities of the road surface. It is perform its function without impairing the stability, steering (or) general handling of the vehicle. Generally for light vehicles, coil springs are used as suspension system. A spring is an elastic object used to store mechanical energy and it can be twist, pulled (or) stretched by some force and can return to their original shape when the force is released. The present work attempts to analyze the safe load of the light vehicle suspension spring with different materials. This investigation includes comparison of modeling and analyses of primary suspension spring made of low carbon-structural steel and chrome vanadium steel and suggested the suitability for optimum design. The results show the reduction in overall stress and deflection of spring for chosen materials.
Keywords*:* coil springs, primary suspension system, modeling, static analysis, ANASYS 12.0, PRO-E

I. INTRODUCTION

The complete suspension is to observe the vehicle body from road shocks and vibrations otherwise it is transferred to the passengers and load. It must keep the tires in contact with the road, regardless of road surface. A basic suspension system consists of the parts springs, axles, shock absorbers, arms rods and ball joints. The spring is the flexible component of the suspension. Modern passenger vehicles usually use light coil springs. Light commercial vehicles have heavier springs than passenger vehicles, and can have coil springs at the front and leaf springs at the rear. Each side of the vehicle wheels connected by solid or beam, axles. Then the movement of a wheel on one side of the vehicle is transferred to the other wheel with independent suspension, the wheel can move independently of each other, which reduce body movement. And it is also prevents the other wheel being affected by movement of the wheel on the opposite side and reduces body movement.

Coil springs are used on the front suspension of most modern light vehicles. Then the spring act as an elastic object used to store mechanical energy. They can twist, pulled (or) stretched by some force and can return to their original shape when the force is released. A coil spring is made from a single length of special wire, which is heated and wound on a former, to produce the required shape. The load carrying ability of the spring depends on the diameter of the wire, the overall diameter of the spring, its shape, and the spacing of the coils.

Normally, helical spring failure occur due to high cyclic fatigue in which the induced stress should remain below the yield strength level and also with poor material properties. K Pavan Kumar[1] et.al. (2013) discussed about the static analysis of primary suspension system, their work is carried 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 conventional steel helical spring 60Si2MnA is proved as best material for helical spring by reduction of deflection and overall stress. Priyanka Ghate[2] et al. investigated 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. The dynamic analysis was performed using ADAMS/Rail at four different velocities and three different track conditions and numerical simulation also carried out. The results shows that the stress value obtained from numerical simulations in ADAMS was verified with analytical design calculations for the spring and the ride index was found to 1.78 which was 8% better than the earlier spring. It is concluded that the new spring design can enhance durability and ride index

Mehdi Bakhshesh[3] et al.(2012) worked on optimum design of steel helical spring related to light vehicle suspension system under the effect of a uniform loading has been studied and finite element analysis has been compared with analytical solution. This spring has been replaced by three different composite helical springs which are made of E-glass/Epoxy, Carbon/Epoxy and Kevlar/Epoxy. The optimum design based on the parameters of weight, maximum stress and deflection and have been compared with steel helical springs. It has been shown that spring optimization by material spring changing causes reduction of spring weight and maximum stress considerably. N.K.Mukhopadhyay[4] et.al (2006), investigation on the premature failure of suspension coil spring of a passenger car, which failed during the service within few months and identified the reasons for the failure. This investigation micro structural analysis,SEM analysis, hardness testing, and chemical analysis. The results stated that the inherent material defect in association with deficient processing led to the failure of the spring. Reduction in weight of automobile vehicles is economical for automotive industry, so P.S.Valsange[5] et. al (2012), investigated the effect of parameters on the quality of coil springs. And also estimated factors affecting on the strength of coil spring, by using F.E.A. approaches. Thus the springs are to be designed for higher stresses with small dimensions to have better spring design which leads to save in material and reduction in weight. It is observed that if the inner side of the coil spring is shot peened the stresses on inside coil surface reduces and fatigue life of coil spring increases. S.S.Gaikwad[6] et.al (2013),examined on Static Analysis of Helical Compression Spring Used in Two-Wheeler Horn, using NASTRAN solver and compared with analytical results .Static analysis determines the safe stress and corresponding pay load of the helical compression spring. it is concluded that the maximum safe pay load for the given specification of the helical compression spring is 4 N. At lower loads both theoretical and NASTRAN results are very close, but when load increases the NASTRAN results are uniformly reduced compared to theoretical results. The objective of the present work is analyze the safe load of the light vehicle suspension coil spring with different materials and attain the optimum design.

II. METHODOLOGY

In this work modeling and analysis has been carried out on different materials for helical spring. The materials chosen are chrome vanadium steel material, low carbon structural steel material; the specifications, modeling and analysis are as follows.

2.1 Specifications of helical spring and Material data

Specification of spring:

Wire diameter =9.49 mm, Coil outer diameter =56.94 mm, Coil free height =152 mm, No.of active coils =11, pitch =13.8 mm,and test load on each spring =2750 N

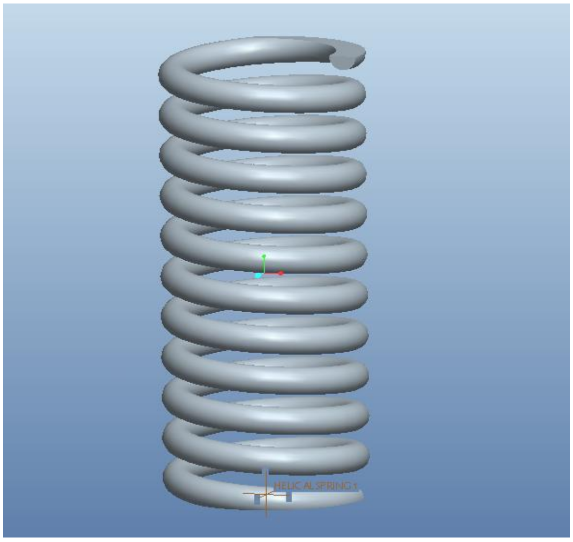
Material property:

For Chromium vanadium steel material properties are Young’s modulus =207000MPa, Poisson ratio =0.27, Density =7860kg/m^3

For low carbon structural steel material properties are Young’s modulus =198000MPa, Poisson ratio =0.37, Density =7700 kg/m^3

2.2 Modeling of helical spring

A coil spring is designed by using PRO-E as per the specifications and analyzed by ANSYS 12.0 software. In this the spring behavior will be observed by applying different materials loads, to optimum stresses and the result shows best material. Model of the spring will be first created by using PRO-E. begin by drawing a line of 152 mm length and it is the free height of spring. The line is at a distance of 56.94 mm from vertical axis and it is outer diameter of the coil. Next enter the pitch of spring. Pitch is calculated by free height of coil the spring divided by the number of turns. In this 152/11=13.8mm. create the circle of wire diameter 9.49mm of spring and create Solid model of Helical spring as shown in figure 1



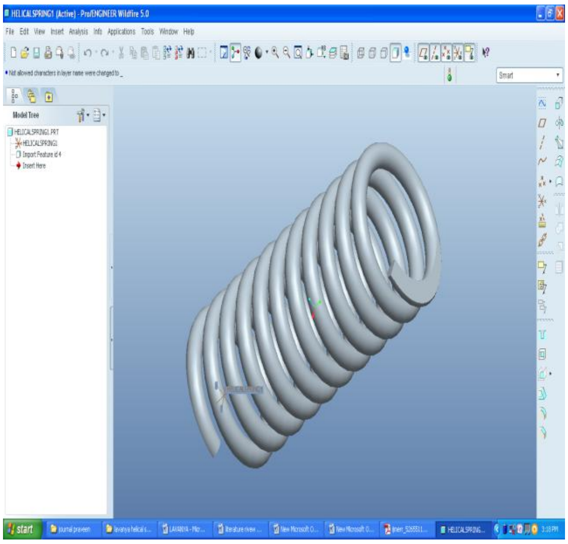


Fig.1: Solid model of Helical spring

2.3 Analysis of modeled helical coil spring

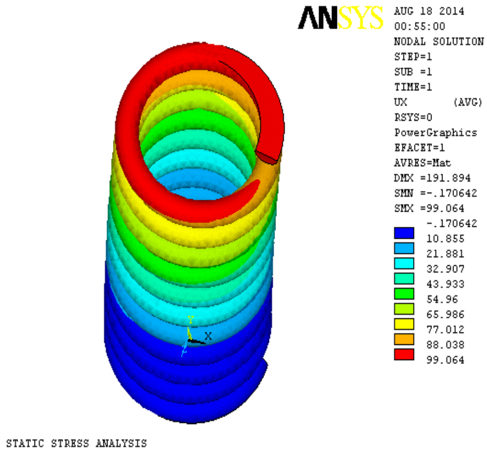
A model of the helical spring was created using Pro/Engineer software. Then the model will be imported to analysis using FEA uses a complex system of points called nodes which make a grid called a mesh. This mesh is programmed to contain the material and structural properties which define how the structure will react to certain loading conditions. Nodes are assigned at a certain density throughout the material depending on the anticipated stress levels of a particular area. This model includes static analysis with different materials to optimum the stresses.

Static analysis:

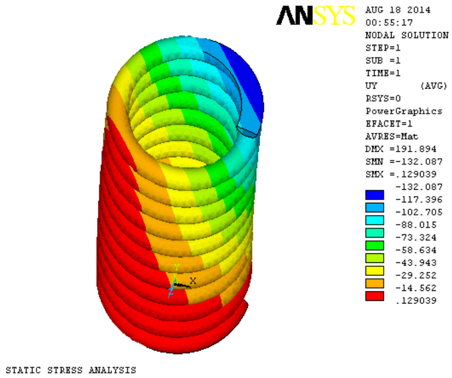
Structural analysis consists of linear and non-linear models. Linear models use simple parameters and assume that the material is not plastically deformed. Non-linear models consist of stressing the material past its elastic capabilities. The stresses in the material then vary with the amount of deformation as in it.

Static analysis of chrome vanadium material:

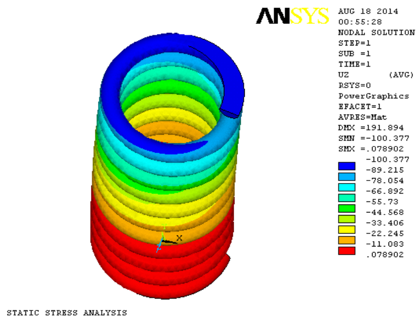
The static analysis is carried out to a given material properties and loading boundary conditions as mentioned in material specifications. The displacements in x- direction, y-direction, z-direction and displacement vector sum values for stress and strain are show in figure2. This analysis also shows Von misses stress, vonmises strain, stress intensity and total mechanical strains are shown in figure.3



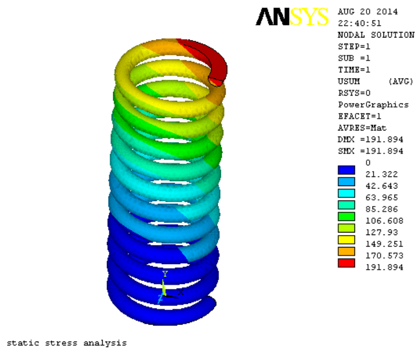
Displacement in x- direction



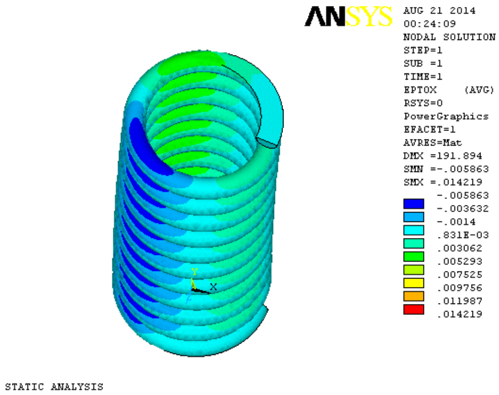
Displacement in y- direction



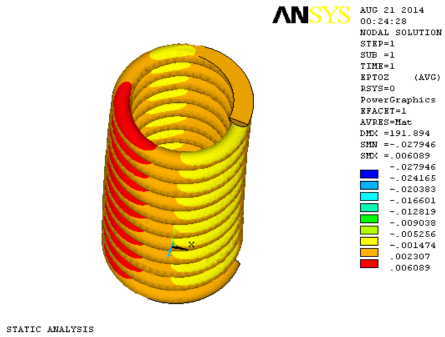
Displacement in z- direction



Displacement vector sum

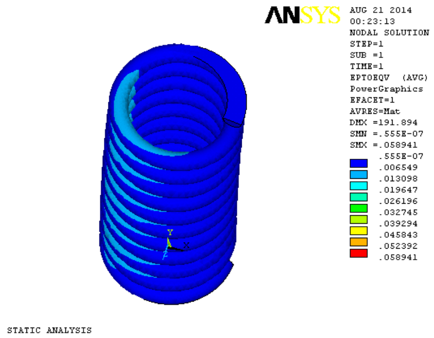


Displacement in x- direction(STRAIN)

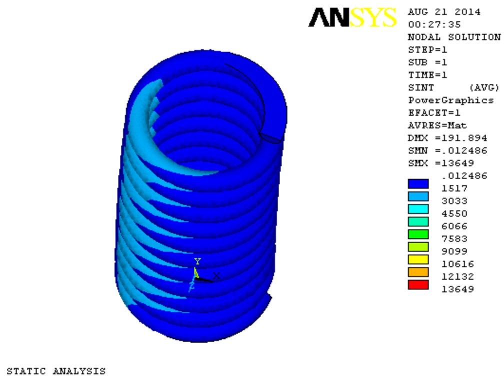


Displacement in Y- direction (STRAIN)

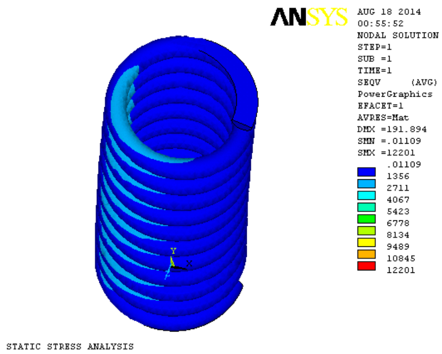
Fig.2**:** Displacements of chrome vanadium helical spring



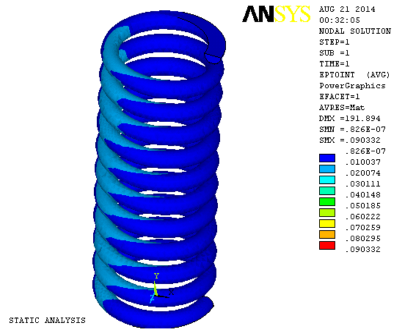
Vonmises strain



von mises stress



stress intensity

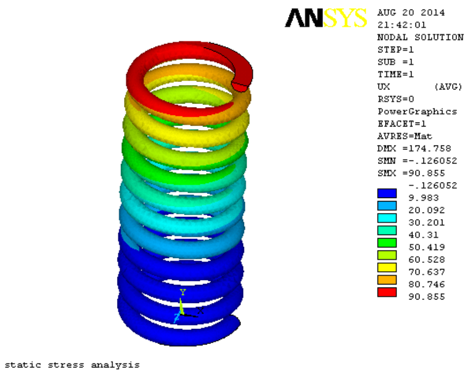


Total mechanical strain

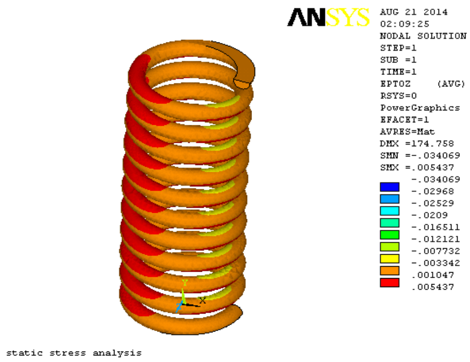
Fig..3**:** Stress and stress of a chrome vanadium helical spring

Static analysis of low carbon structural steel:

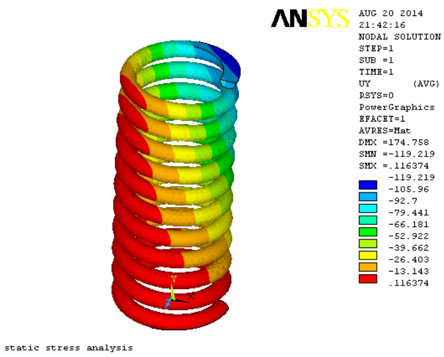
The static analysis is carried out to a given material properties and loading boundary conditions as mentioned in material specifications. The displacements in x- direction, y-direction, z-direction and displacement vector sum values for stress and strain are show in figure.4. This analysis also shows Von misses stress, vonmises strain, stress intensity and total mechanical strains are shown in figure.5



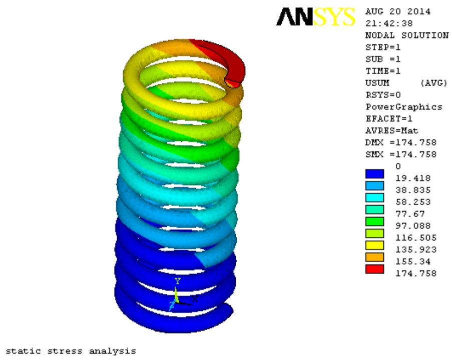
Displacement in x- direction



Displacement in Z- direction (STRAIN)

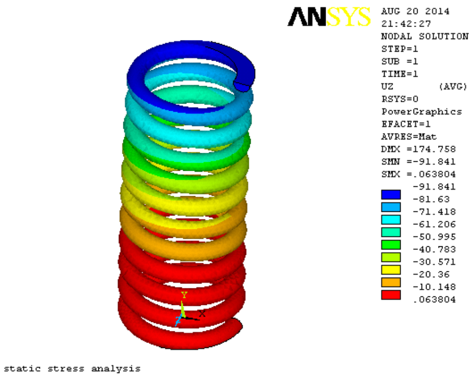


Displacement in y- direction

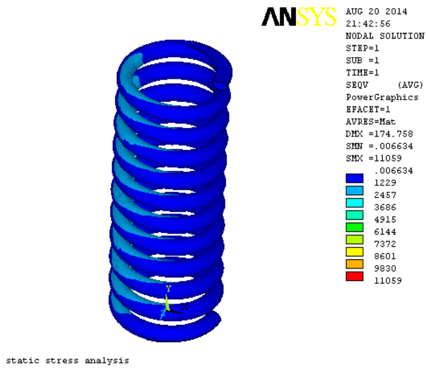


Displacement vector sum

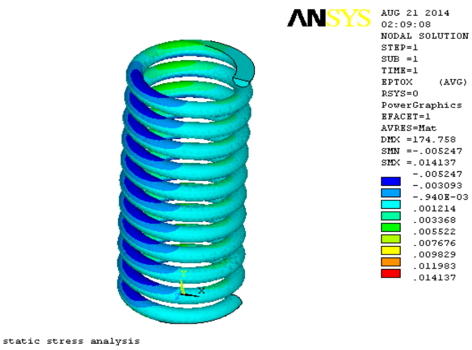
Figure.4 Displacements of low carbon helical spring



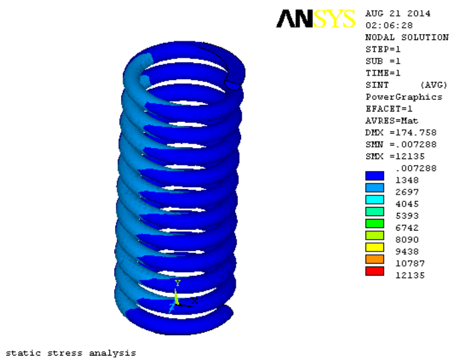
Displacement in z- direction



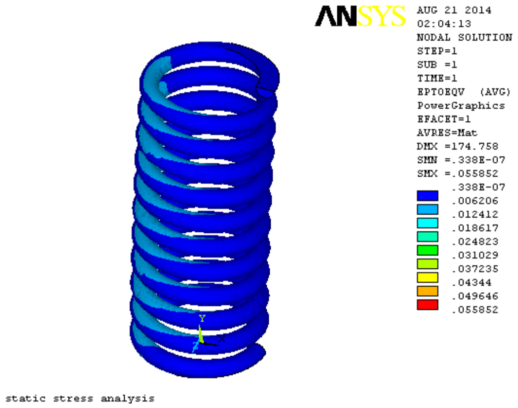
vonmises stress



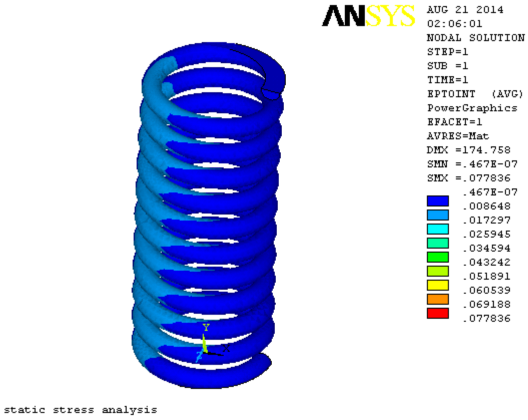
Displacement in x- direction (STRAIN)



stress intensity



vonmises strain



total mechanical strain

Figure.5 Stress and Strains of low carbon helical spring

III. RESULT AND DISCUSSION

The static analysis of helical compression spring is carried out in ANSYS with two different materials such as chromium vanadium steel and low carbon structural steel. Hence the results are analyzed are displacements in x,y,z- direcions are presented in table.1 vonmises stress intensity, vonmises strains and total mechanical strain values are shown in table,2

Table.1 Displacements of helical spring

Chromium vanadium helical compression spring displacement results				
Static analysis				
	X Displacement	Y Displacement	Z Displacement	Displacement vector sum
stress	99.06	0.1290	0.7890	191.89
strain	0.0421	0.0564	0.0060	--
Low carbon structural steel helical compression spring displacement results				
Static analysis				
	X Displacement	Y Displacement	Z Displacement	Displacement vector sum
stress	90.983	0.116	0.6380	174.75
strain	0.0141	0.060	0.0054	--

Table.2 Stress and strains of helical spring

Comparison of result for two different materials			
S.No.	Description	Chrome vanadium steel	Carbon structural steel
1	Von misses stress in MPa	12201	11059
2	Von misses strain	0.058941	0.055852
3	Stress intensity in MPa	13649	12135
4	Total mechanical strain	0.090332	0.055852

The failure of spring takes place due to high cyclic fatigue and with poor material properties to enhance the cyclic fatigue and optimize the induced stress and strains the present work is carried on optimum design and analyses of a suspension spring of a motor vehicle in this connection the helical suspension spring modeling was done in Pro/E as per the spécifications then after the model is imported to ANSYS in which ststic analysis is carried out for two different materials such as Chromium vanadium steel (existing material) and low carbon stractural steel (praposed material) with a expected same load conditions. The simulation was carried out for two materials in ANSYS and compared which results reduced the stress strain values for a new design are shown in Table..2

IV. CONCLUSION

The present work is optimum design and analysis of a suspension spring for motor vehicle subjected to static analysis of helical spriing the work shows the strain and strain response of spring behavior will be observed under prescribed or expected loads and the induced stress and strains values for low carbon structural steel is less compared to chrome vanadium material also it enhances the cyclic fatigue of helical spring. The following points are drawn from the analyses results.

i. The vonmises stress induced in chromo vanadium steel is 12201MPa and for low carbon structural steel is 11059MPa.
ii. The vonmises strains induced in chromo vanadium steel is 0.05891 and for low carbon stractural steel is 0.055852.
iii. The stress intensity in chromo vanadium steel is 13649MPa and for low carbon structural steel is 12135MPa.
iv. The total mechanical strain induced in chromo vanadium is 0.090332 and for low carbon stractural steel is 0.055852.

Based on the modeling and analyses conclude that the low carbon structural steel material is best suitable for production of helical spring's compared to chromo vanadium steel materials which are used in motor vehicles.

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