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ANALYSIS OF STAINLESS STEEL BASED HELICAL SPRING USING FEM

Siddharth Shankar Dubey
ME IVth sem student, Department of Mechanical Engineering ,Jabalpur Engineering College Jabalpur (M P), India
Prof. A.K. Jain
Associate professor , Department of Mechanical Engineering ,Jabalpur Engineering College Jabalpur (M P), India

Abstract-A helical spring is a mechanical device typically used to store and subsequently release energy, to absorb shock, or to maintain force between a contracting surface. The current work is being carried out on modeling, and the suspension spring analysis is to replace the steel helical spring used in popular two-wheeled vehicles. The use of traditional steels such as spring increases the weight and energy of the required manufacturing process more, so manufacturers are willing to use composite materials that are lightweight and also have corrosion resistance, and can also withstand high temperatures. Composite materials are more expensive to manufacture than steel springs. The use of composite materials is beneficial if the manufacturing process is standardized, as it can increase the efficiency of the vehicle's commitment to overcome the cost of materials.

Keywords- Helical springs, Catia software, Ansys software.

1 Introduction

In order to conserve natural resources and save energy, weight loss has been the main focus of automobile manufacturers in the modern world. Weight reduction can be achieved mainly through the introduction of better materials, improvement and new manufacturing techniques. The helical spring used to suspend vehicles is one of the target items for weight loss as it accounts for 10-20% of the unsuspended weight. This results in a vehicle with greater fuel efficiency and improved driving characteristics.

The helical spring is a simple form of spring, commonly used for suspension in automobiles. It is also one of the oldest forms of shock absorbers; It dates back to the Middle Ages. The advantage of a helical spring over a spring is that the end of the helical spring can be directed along a specified path. This is due to the fact that vehicle components are subjected to a variety of stress loads such as shocks from road irregularities tracked by the road wheels, sudden loads due to wheel movement over bumps etc. Helical springs are most affected due to fatigue loads, since they are part of the unscrewed mass of the car.

The fatigue behavior of glass fiber reinforced plastic (GFRP) composite materials has been studied in the past. The theoretical equation was formulated to predict fatigue life using the fatigue modulus and its degradation rate. This relationship is simplified by the stress failure criterion of practical application. A prediction method for the stress strength of composite structures is presented at a random combination of frequency, strain ratio and temperature.

Figure 1 Stainless Steel Coil Spring

Figure 2 Suspension Coil Spring

2 CAD Geometry

1. Spring Constant
2. Travel to shut height
3. Height
4. Internal Diameter
5. Wire Diameter
6. Number Of Coil
7. Weight

The geometry of the spring can also be changed by changing the number of coils or changing the diameter of the wire. The number of coils can be reduced, the shear modulus of the material can be increased, or the wire diameter can be increased to help the design achieve the hardness needed to compete with the titanium spring. The spring geometry was repeated between CAD and analysis to arrive at a geometry to be tested for different materials and wind angles applicable to the final design. This final spring design consists of the following dimensions.

1. Height
2. Internal Diameter
3. Wire Diameter
4. Composite Outer wire Diameter
5. Total Number of Coils

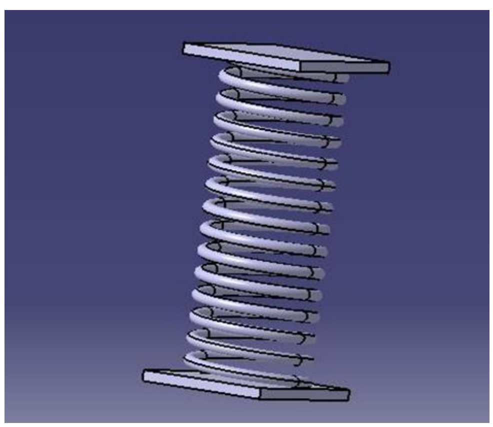

Figure 3 Spring CAD design

3 Methodology

CATIA V5 software is used to create the helical spring. Catia software is capable of developing various types of engineering, assembly, sheet metal work, etc. using different type of modules. To develop the 3D model of the helical spring, the assembly of the part design was used.

4 Simulation

Finite Element Method (FEM) provides a platform to achieve approximate solution to real problems. The finite element method is a numerical method for determining the approximate solution to engineering and scientific problems. In FEM, the complex region that defines a continuum is broken down into simple geometric shapes called elements. The governing properties and relationships are assumed on these elements and expressed mathematically in terms of unknown values at specific points in the elements called nodes.

5 Modeling

The performance of the helical spring will be observed by selecting the different properties of the materials to determine the optimum pressures and the result to select the most suitable material. The Spring model will be generated first using CATIA V5.

6 Mesh

The mesh has a very important role in finite element analysis. The grid divides an element into a finite number of elements. Generally, according to the requirements, the researcher takes the fine, medium and coarse mesh size. The simulation time is directly proportional to the mesh shown on the mesh coil spring.

7 Composite in ANSYS Static Structure

STATIC STRUCTURE is the preprocessing module for composite analysis provided by ANSYS. It includes necessary tools to allow the user to orientate the fiber and build a solid or shell composite part to be used in an analysis module.

Figure 4 Static Structure Composite Preprocessing

The CAD geometry is imported into a fixed structure as a surface and the inner surface of the wire is used which will have composite layers built from this inner diameter to the outer diameter of the spring. In the mechanical unit, the surface is a mesh that is then extruded to form solid elements in the formation unit after the mechanics to create a three-dimensional composite.

The size function used for the mesh was set to 'Curvature' to allow the mesh to follow the small radius of the surface and the size was set to a maximum face size of 0.02" and a minimum face size of 0,01". In a STATIC STRUCTURE configuration, the composite deck received a T1000G material that was created using the composite properties offered by Toray for its T1000G fibres. Then a stack of material is used to approximate the up and down movement of the longitudinal axis by the thread winding guide. The first pass through the device will leave a positive wind angle, followed by a negative wind angle as it applies layers of resin-impregnated fibers. The positive and negative fiber angle is determined at this point and will be analyzed later to improve the design.

8 Static Structural Analysis

Nonlinear analysis is used in the static structural unit and the pretreatment of the composite, wires and plates is fed into a static structural analyzer. All contacts are applied as bonded. The displacement limit condition is applied to the top plate when testing the spring to fail at a full pressure of 2.25 inches or a force of 1,000 Newtons is applied to test the spring stiffness by displacement measurement. For a spring designed for a spring constant of 500 lbs/in, it should travel about 1 inch when a force of 500 lbs is applied. 19 The solutions are the displacement of the spring in the y direction and a composite failure tool set to the stress limits of the composite is applied. If the composite failure instrument shows a value higher than 1, the element has encountered a stress value above the stress limit set by the material.

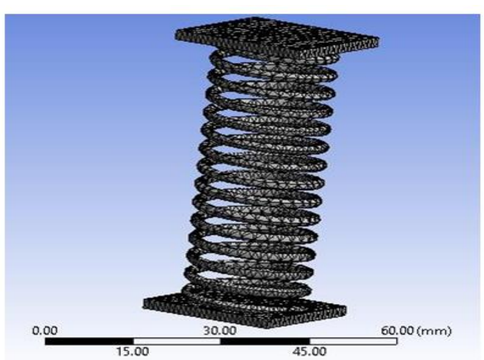

Figure 5 Composite Meshing

9 Results and Discussion

CATIA V5 software is used to create the helical spring. Catia software is capable of developing various types of engineering, assembly, sheet metal work, etc. using different type of modules. To develop the 3D model of the helical spring, the assembly of the part design was used. This section contains a static analysis of carbon steel plates. In this study, 26,290 nodes and 8753 items were selected in the networking region. The node is the intersection of the elements.

Total Deformation

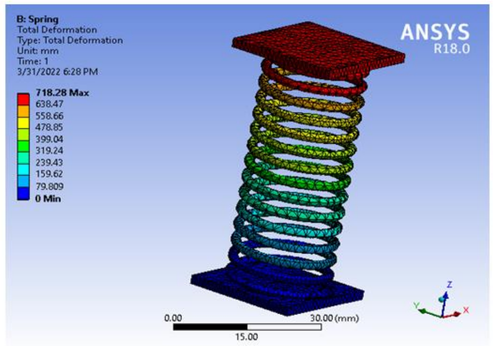

Figure 6 Total Deformation

Total deformation is the deformation option that enables to model, in three coordinates (X, Y, Z), where the load is applied from the top surface and makes the bottom surface constant then the constant load of 1000 N will start compressing the spring as The spring stores the compressive force and then restores its original shape.

Normal Elastic Strain

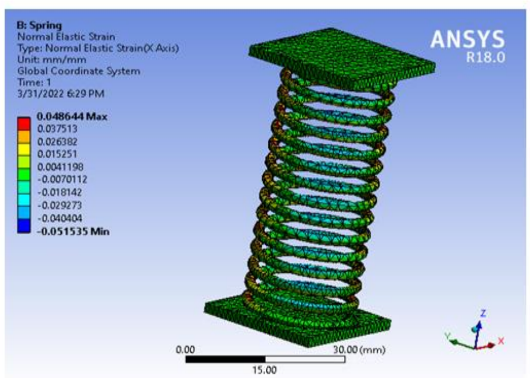

Figure 7 Normal Elastic Strain

It is simply the ratio of the change in length to the original length. The deformation applied perpendicular to the cross section is considered normal, while the deformations applied parallel to the cross section are common strains, for linear elastic materials the stress is linearly related to the stress according to Hooke's law.

Normal Stress

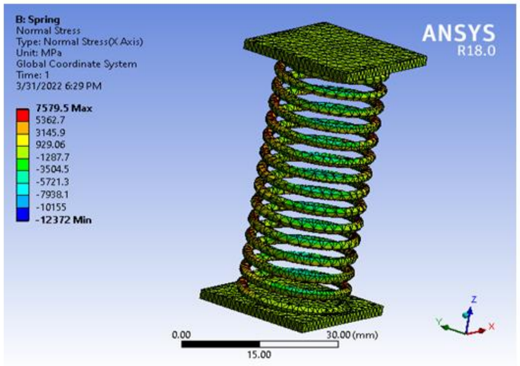

Figure 12 Normal Stress

The stress is said to be a normal stress when the direction of the deforming force is perpendicular to the cross-sectional area of the body. Wire length or body size changes pressure will be normal.

Shear Elastic Strain

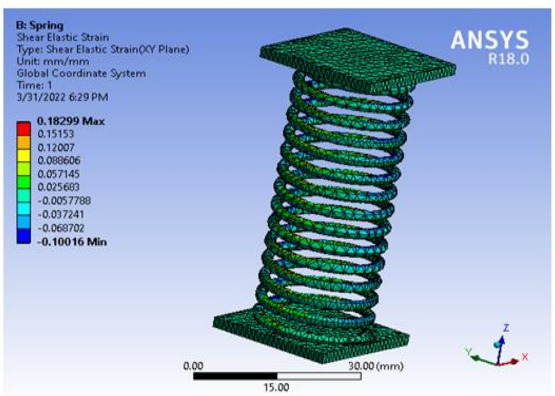

Figure 8 Shear Elastic Strain

Shear stress is related to the shear modulus, which has a modulus of elasticity for a given material that expresses the ratio between the force per unit area (shear stress) deforming the material and the shear resulting from this force.

Shear Stress

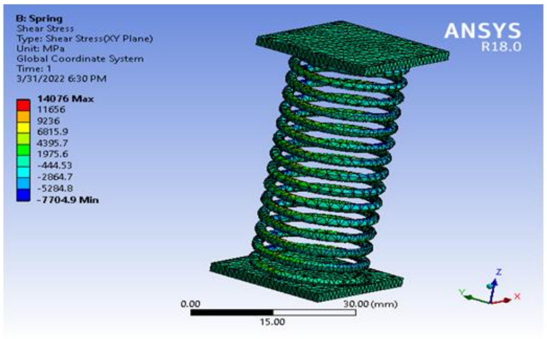

Figure 9 Shear Stress

Shear stress arises due to shear forces. They are a pair of forces acting on opposite sides of the body with the same magnitude and opposite direction. Shear stress is a vector quantity. Which means that the trend here is also included with the magnitude. SI unit of shear pressure N/m^2 or Pa.

Stress Intensity

The stress intensity factor is the magnitude of the stress singularity at a mathematically acute fault tip in a linear elastic material. Each fracture style has an associated stress severity factor.

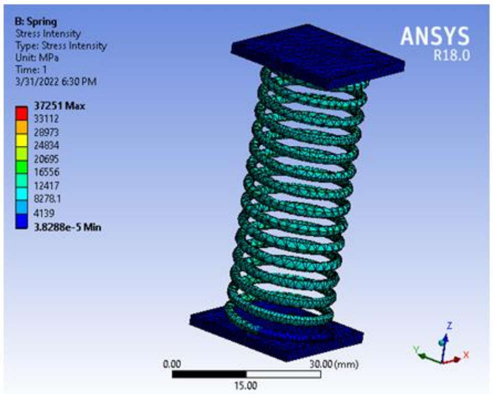

Figure 10 Stress Intensity

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Equivalent Elastic Strain

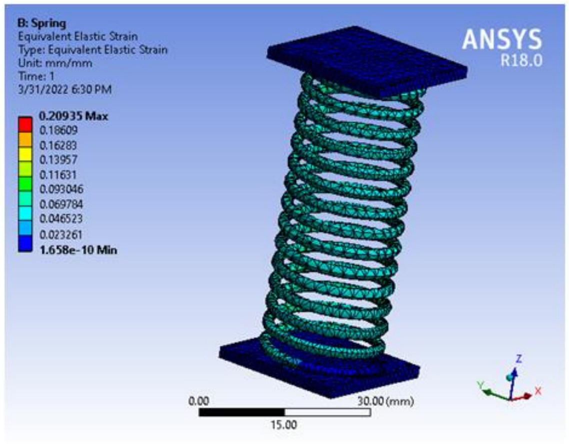

Figure 11 Equivalent Elastic Strain

Equivalent elastic strain is defined as the maximum stress values to which the object bounces back to the original shape when the load is removed. Elastic limit is defined as the point on the stress-strain curve where an object changes its elastic to plastic behaviour.

Equivalent Stress

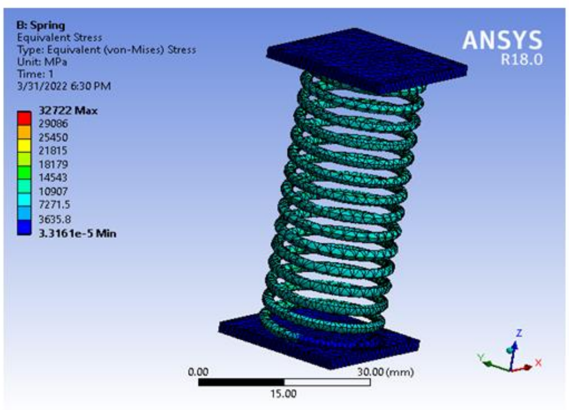

Figure 12 Equivalent Stress

Equivalent stress theory, also called deformation energy theory or von mises theory, states that the maximum equivalent stress at elements stressing the material or part must be smaller than the yield strength of that material used. The maximum equivalent stress theory applies to ductile materials.

10 Conclusions

The present project work is based on the optimization design and analysis of suspension compression helical spring for the automotive industries. Spring static analysis, responses are stress, helical spring stress was analyzed under desired and expected load. The simulated stress and tension values for carbon steel are lower compared to stainless steel, and they improve the stress life of the helical spring.

The following conclusion was drawn from the analysis of the results.

1. The equivalent stress (vonmises stress) produced by stainless steel is 1102 MPa.
2. The equivalent strain (vonmises strains) induced in stainless steel is 0.0057
3. The pressure density of stainless steel is 1211.3 MPa.
4. The resulting shear stress in stainless steel is 546.29.

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