3rd International Conference on Research Developments in Applied Science, Engineering & Management
The Indian Council of Social Science Research (ICSSR)
Panjab University Campus, Chandigarh (India)
AEM–2018
Conference World
19th August 2018 www.conferenceworld.in ISBN : 978-93-87793-43-9

A Study of Helical Springs

Upendra Sharan Gupta[1] , Abhinav Kosta[2] ,

Abhishek Pahwa[3] , Ayush Awasthi[4]

[1]Reader Dept. of Mech. Engineering, SVITS, Indore, India

[2]UG Scholar Dept. of Mech. Engineering, SVITS, Indore, India

[3]UG Scholar Dept. of Mech. Engineering, SVITS, Indore, India

[4]UG Scholar Dept. of Mech. Engineering, SVITS, Indore, India

ABSTRACT

Springs are widely used in many engineering applications due to their various importance. Spring act as a flexible joint in between two parts or bodies. The free vibration problem of the springs has drawn much attention in the last decades. Helical spring is a mechanical device, which is typically used to store energy and subsequently release it, to absorb shock, or to maintain a force between contacting surfaces. They are made of an elastic material formed into the shape of a helix which returns to its natural length when unloaded. Among the different types of mechanical springs, helical springs are commonly integrated as parts of many mechanical systems, such as shock absorbers.

Keywords: *absorb shock, flexible joint, store energy, elastic material,helix*

1. INTRODUCTION

The primary function of a mechanical spring is to store energy by deflections or distortions under an applied load. The spring can be considered as an elastic member that exhibits linear elastic properties provided that the material is not stressed beyond its elastic limit. This spring's practical application can be found in brake controllers, where it is used to regain an equilibrium state once hydraulic pressure vanishes. The spring is required to have significantly large lateral stiffness to minimize lateral displacements. They are commonly used in vehicle suspension. These springs are compression springs and can differ greatly in strength and in size depending on application. In engines these springs are compression springs and play an important role in lifting the valves that feed air and let exhaust gasses out of the combustion chamber. According to the different ways of

ISBN : 978-93-87793-43-9

loading applied, helical springs can be divided into three kinds: compression springs, tension springs and torsion springs, and they are mainly with either round section or square section.

2. MODELLING OF HELICAL SPRING (ONE DEGREE FREEDOM SYSTEM)

2.1 GEOMETRICAL AND MATERIAL PARAMETERS

In this study we carried out the compression test on helical cylindrical spring and helical conical spring. The dimensions of these helical springs are given below:

Helical Cylindrical Spring

Total height= 60mm

External diameter (OD) = 34mm

Mean diameter (ID) = 15mm

Wire diameter = 4.2mm

No. of active turns = 7

Helical Conical Spring

Total height = 60mm

External diameter (Bigger side) = 34mm

External diameter (smaller side) = 24mm

No. of active turns = 7

Wire diameter = 4.2mm

Following values of material parameters (spring steel grade II) are taken for FE simulation purpose:

Young's Modulus = 2.1e5 N/mm^2 , Density = 7.86e-9 Kg/mm^3 , Possion's ratio = 0.3

As per the Hooke's law "A material is said to be elastic if, when deformed by an applied force, it returns to its original shape when the force is removed. There are many familiar examples of this, such as steel springs, rubber bands."

ISBN : 978-93-87793-43-9

Here the coefficient of friction that we make in use is 0.2.

2.2 MODELING USING CATIA V5R12

In this project study we make the use of CATIA V5R12 for modeling purpose of the helical cylindrical spring and helical conical spring. Here, we carried out the modeling of our helical springs using the following parameters that we know. We keep constant pitch in both helical cylindrical and conical spring. We use the helical sweep command that specially used in this software for modeling helical springs. As per our design, wire diameter, spring height, pitch value, mean diameter is defined here to model the helical cylindrical and helical conical springs. CATIA V5R12 has the capability of transferring its made software into other CAD software's in different format like IGES.

CATIA V5R12 is developed by parametric technology corporation and this is one of the fastest growing solid modeling software. As a parametric featured based solid modeling tool, it not only unites the 3D parametric features with 2D tools, but also addresses every design-through-manufacturing process. The solid modeling tool used here allows us to easily import the standard format files with an amazing compatibility to other software's.

CATIA V5R12 wildfire 4.0 is a powerful program used to create complex design with great precision. The design intent of any three dimensional model or an assembly is defined by its specification or its use. Here, to make the designing process simple and quick, this software package has divided the steps of designing into different modules. For getting better results each step of the designing is completed in a different specific module. Design process consists of the following of the following steps:

- Sketching using the basic sketch entities
- Converting the sketch into features and parts
- Assembling different parts and analyzing them
- Documenting parts and the assembly in terms of drawing view
- Manufacturing the final part and assembly

Feature Based Nature

CATIA V5R12 is a feature based solid modeling tool. A feature is defined as the smallest building block or any solid model created in this software is an integration of a number of building blocks. Each feature can be edited individually to bring any changes in the solid model. The use of feature based property provides greater flexibility for the parts to be created.

Bidirectional Associative Property

ISBN : 978-93-87793-43-9

The Bidirectional associative nature of this software is defined as its ability to ensure that if any modification is made in a particular model in one mode, the corresponding modifications are also reflected in the same mode in the other modes.

Parametric Nature

CATIA V5R12 is parametric in nature, which means that the features of a part become interrelated if they are drawn by taking the reference of each other. We can redefine the dimensions or attributes of the feature at any time. The changes will propagate automatically throughout the model. Thus they develop the relationship among themselves. This relationship is known as the parent-child relationship. So, here if we want to change the placement of the child feature, you can make alterations in the dimensions of the references and hence change the design as per your requirement.

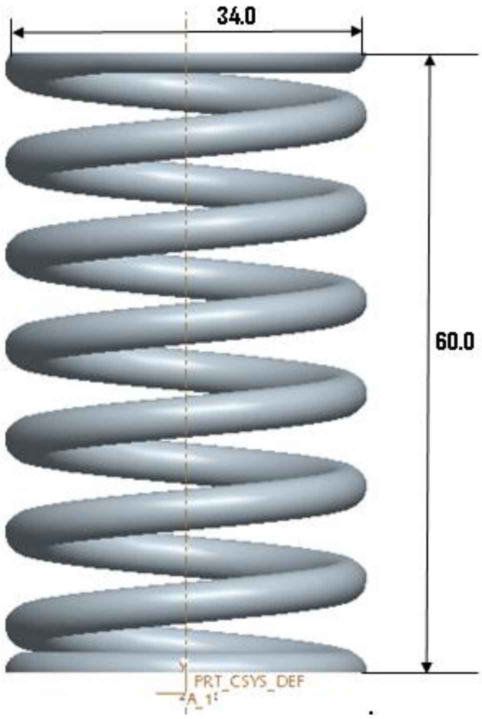

Figure 1.1: *Model of helical cylindrical spring using CATIA V5R12*

3. FEM SIMULATION OF HELICAL SPRINGS

Helical Cylindrical Spring

This sub heading includes the FEM simulation of the helical cylindrical spring and helical conical spring with the arrangement (punch and base arrangements) that we use in the experimental work. Our area of interest involves the deflection (compression) of models and the reaction forces getting against that deflection.

ISBN : 978-93-87793-43-9

Punch and base arrangements are defined as the analytical rigid parts. A rigid body is a collection of nodes and elements whose motion is governed by the motion of single node or reference point known as rigid body reference node. They are convenient method of specifying certain contact interactions.

Co-efficient of friction = 0.2, Contact defined = Discritization method, surface to surface, Friction formulation = Penalty

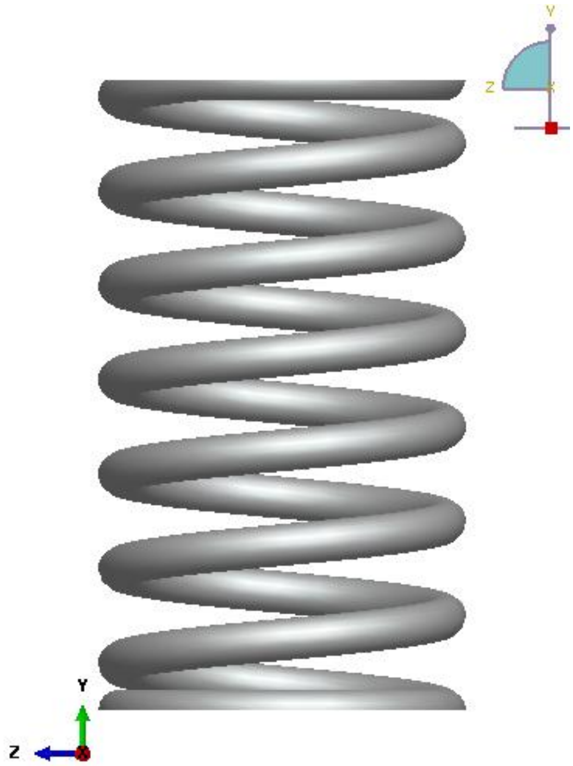

Figure 1.2: *Model of helical cylindrical spring in CATIA V5R12.*

4. FEM ANALYSIS OF HELICAL SPRING (ONE DEGREE FREEDOM SYSTEM)

MESH:

Entity	**Size**
Nodes	7105
Elements	23515

ELEMENT TYPE:

Connectivity	**Statistics**
TE4	23515 (100.00%)

Properties.1

ISBN : 978-93-87793-43-9

Material apply to

Part1.1 - OCTREE Tetrahedron Mesh.1 : Part1.1

Material	Steel : Structural (ASTM-A36)
Young Modulus	2e+011N_m2
Poisson Ratio	0.266
Density	7860kg_m3
Thermal Expansion	0.0000117
Yield Strength	2.5e+008N_m2

Static Case

Boundary Conditions

STRUCTURE Computation

Number of nodes : 7105

Number of elements : 23515

Number of D.O.F. : 21315

Number of Contact relations : 0

Number of Kinematic relations : 0

ISBN : 978-93-87793-43-9

Linear tetrahedron : 23515

RESTRAINT Computation

Name: RestraintSet.1

Number of S.P.C : 711

LOAD Computation

Name: LoadSet.1

Applied load resultant :

Fx = -1 . 943e-015 N

Fy = -5 . 600e+002 N

Fz = -3 . 529e-015 N

Mx = 3 . 086e-008 Nxm

My = -1 . 627e-015 Nxm

Mz = 4 . 026e-008 Nxm

STIFFNESS Computation

Number of lines : 21315

Number of coefficients : 364785

Number of blocks : 1

Maximum number of coefficients per bloc : 364785

Total matrix size : 4 . 26 Mb

SINGULARITY Computation

Restraint: RestraintSet.1

Number of local singularities : 0

Number of singularities in translation : 0

Number of singularities in rotation : 0

Generated constraint type : MPC

CONSTRAINT Computation

Restraint: RestraintSet.1

ISBN : 978-93-87793-43-9

Number of constraints : 711

Number of coefficients : 0

Number of factorized constraints : 711

Number of coefficients : 0

Number of deferred constraints : 0

FACTORIZED Computation

Method : SPARSE

Number of factorized degrees : 20604

Number of supernodes : 2750

Number of overhead indices : 106422

Number of coefficients : 1318251

Maximum front width : 351

Maximum front size : 61776

Size of the factorized matrix (Mb) : 10 . 0575

Number of blocks : 2

Number of Mflops for factorization : 1 . 561e+002

Number of Mflops for solve : 5 . 376e+000

Minimum relative pivot : 2 . 681e-007

DIRECT METHOD Computation

Name: StaticSet.1

Restraint: RestraintSet.1

Load: LoadSet.1

Strain Energy : 4.227e+001 J

Equilibrium

Components	Applied Forces	Reactions	Residual	Relative Magnitude Error
Fx (N)	-1.9429e-015	-2.5078e-007	-2.5078e-007	6.3013e-010
Fy (N)	-5.6000e+002	5.6000e+002	-9.1975e-008	2.3110e-010
Fz (N)	-3.5288e-015	-1.1468e-007	-1.1468e-007	2.8815e-010
Mx (Nxm)	3.0860e-008	-1.4148e-007	-1.1062e-007	3.9150e-009

ISBN : 978-93-87793-43-9

My (Nxm)	-1.6265e-015	-1.7423e-008	-1.7423e-008	6.1660e-010
Mz (Nxm)	4.0259e-008	-2.1467e-008	1.8792e-008	6.6506e-010

V.CONCLUSIONS:

1. Making the use of finite element method in helical springs simulation work gives a very fast and precision process and results. Designers will be able to simply obtain the helical springs characteristics in terms of their uniformly deformation, stiffness characteristic of the structure etc.
2. Maximum shear stress always occurs at the inner side of the spring. Hence the failure of the spring always initiated from the inner radius of the spring.
3. FEM application in numerical optimization technologies provides the missing link from analysis response into a fast and optimum design. The immediate impact is the potential savings in the engineering cost since the iteration can be done in the automatic process.
4. Validation of the results was done by using FEM simulation with the experimental results at different values of loads applied on the helical spring. Comparison of the loads obtained through experiment and FEM simulation method shows the percentage of deviation in respect of length which is small as shown in table.

REFRENCES-

1. Abaqus Simulia 6.10 © Dassault Systems, 2010.
2. Guo.X and Lu.H, 2009, Optimal Design of Spring of Automobile Clutch, IEEE, Vol 19, pp 206-208.
3. Hong.Y, Park.H.W, Lee.J.W and Hong.D.P, 2010,
4. “Simulation of Clutch Actuation System for Commercial Vehicle”, International Journal of Precision Engineering And Manufacturing, Vol 11, pp. 839-843
5. Maucher. P. I., 1986, “Optimized Clutch Design Release Load and Operating Comfort” Kupplungen Clutches
6. Embrayages Embragues.
7. Nam.W.H., Lee, C. Y., Chai, Y. S., and Kwon, J. D., 2000,
8. “Finite Element Analysis and Optimal Design of Automobile Clutch Diaphragm Spring", Seoul 2000
9. FISITA World Automotive Congress, pp 12-15.
10. Almen, J. O. and Laszlo A., "The Uniform Section Disc Spring," Trans. ASME, 58(4), pp. 305-314, 1936.
11. Shigley, J.E., “Mechanical Engineering Design”, Tata Mc-Graw Hill, New Delhi, 2001.
12. Schnorr, “Handbook for disc springs” Schnorr Corporation 4355 Varsity Drive Suite A Ann Arbor, MI 48108, 2003