Investigation of Stresses in Helical and Leaf Spring by FEM

Prof. S. D. Khamankar[1], Prof. N. K. Ade[2], Prof. P. H. Sahare[3]

[1]*Associate Professor Department of Mechanical Engineering, R.C.E.R.T. Chandrapur*
[2]*Associate Professor Department of Mechanical Engineering, R.C.E.R.T. Chandrapur*
[3]*Assistant Professor Department of Mechanical Engineering, R.C.E.R.T. Chandrapur*

---***---

Abstract - *Helical and Leaf Springs are important components of an automobile. They are subjected to shear stress and bending stress respectively. Hence, to study the stress variation in both the springs; analytical and FEM method is used. For analysis purpose, model of helical and leaf spring is prepared by taking the actual dimensions of suspension spring of Hero splender and leaf spring of Tata truck. . For FEA, CAD model of helical and leaf spring is prepared using CREO and the analysis is done in ANSYS. The FEA results are compared with Analytical results. Also, the effect of various parameters on the stresses induced in spring is also studied and it is shown in form of a graph.*

***Key Words*: ANSYS, Leaf Spring, Helical Spring, CREO, FEA**

1. INTRODUCTION

A helical spring and leaf spring is typically used in suspension system of automobiles to absorb shocks and vibrations. During its operation, they are subjected to large amount of stresses. The stress induced in Helical Spring depends on various parameters like wire diameter, mean diameter and spring material etc. Similarly, stress induced in a leaf spring depends on breadth and thickness of each leaf, number of full length leaves, number of graduated leaves, and total span of spring and material of spring.

1.1 Introduction of Problem, Scope, Methodology

The helical spring and leaf spring are vital components and its failure is caused due to large amount of stresses induced in it. Failure of these springs may lead to accidents. In this project work, stress analysis of helical and leaf spring have been carried. The specifications for leaf spring of MSRTC bus. They are as follows:

i. Total Number of leaf, n = 13,
ii. Number of full length leaf, n_f = 1,
iii. Number of Graduated leafs, n_g = 12,
iv.Total span length of spring,L=1524 mm, v. Width of each leaf, b = 100 mm,
vi. Thickness of leaf = 12.5 mm,
vii. Radius of curvature, R = 3000 mm, viii. Diameter of EYE D_e= 70 mm,
ix. Modulus of elasticity,E = 200 Gpa,
x. Weight of bus,W_b = 3500 kg,
xi. Total Weight of passengers = 3600 kg.

The specification for helical spring of Hero Splender motorcycle are:

i. Total number of turns, N = 18
ii. Active turns, n = 16
iii. Inactive turns, n' = 2
iv. Wire diameter of spring,d = 7.5 mm v.Outer diameter of spring, Do = 50 mm vi. Inner diameter of spring, Di = 35 mm
vii. Free length of spring, Lf = 160 mm.
viii. F=440 N
ix. Spring material:Carbon Steel SAE1095

Table1: Properties of material SAE 1040

Property	Symbol	Value
Modulus Of Elasticity	E	203×10^3 Mpa
Poisons ratio	μ	0.3

For the purpose of FE analysis, helical spring is fixed at bottom end and axial compression load is applied at the top. The maximum value of shear stress induced in helical spring has been determined using theoretical analysis as well as FEA. Similarly, the analysis of leaf spring is carried out by fixing it at both eye end and applying load at the center where it is supported in suspension system.

2. Theoretical stress analysis- For helical spring

Mean Diameter, Dm = $\frac{Di+Do}{2}$

$$= \frac{35+50}{2}$$

= 42.5 mm

Spring Index, C $\frac{Dm}{d}$

$= \frac{42.5}{7.5}$

= 6

Wahl's Stress Factor,

$K = \frac{4C-1}{4C-4} + \frac{0.615}{C}$

$= \frac{4*6-1}{4*6-4} + \frac{0.615}{6}$

= 1.25

Sys = 670 Mpa

FS = 2

$\tau x = \frac{Sys}{F.S}$

τmax = 335 Mpa (Allowable)

$\tau max = K \times \frac{8F.Dm}{\pi.d^3}$

$= 1.25 \times \frac{8* 440* 42.5}{\pi.7.5^3}$

=141.338 Mpa

As working stress is less than Allowable stress, design is safe,

Maximum Deflection of spring,

$\delta = \frac{8F.Dm^3 n}{G.d^4}$

$= \frac{8*440*42.5^3*16}{80*10^3*7.5^4}$

=20 mm

As Lf is less than 4 times Dm, there is no buckling of spring.

For leaf spring

F = weight of bus + (seat for passenger × weight of each passenger)

= (3500 x 9.81) + (60 × 60 x 9.81)

= 69651 N

Load/spring = $\frac{69651}{8}$

=17413N

BENDING STRESS

In full length leaves

$(\sigma_b)f = \frac{3FL}{2n_g bt^2} \times [\frac{1.5}{1+1.5\times\frac{n_f}{n_g}}]$

$= \frac{3\times17413\times1524}{2\times12\times100\times12.5^2} \times [\frac{1.5}{1+1.5\times\frac{1}{12}}]$

$(\sigma_b)f = 287.5\ N/mm^2$

In graduated leaves

$(\sigma_b)g = \frac{3FL}{2n_g bt^2} \times [\frac{1}{1+1.5\times\frac{n_f}{n_g}}]$

$= \frac{3\times17413\times1524}{2\times12\times100\times12.5^2} \times [\frac{1}{1+1.5\times\frac{1}{12}}]$

$(\sigma_b)g = 190.338\ N/mm^2$

DEFORMATION

$= \frac{3FL^3}{8En_g bt^3} \times [\frac{1}{1+1.5\times\frac{n_f}{n_g}}]$

$\delta = \frac{3*\times17413\times1524^3}{8\times200\times10^3\times12\times100\times12.5^3} \times [\frac{1}{1+1.5\times\frac{1}{12}}]$

= 43.78 mm

3. Preparation of CAD model for helical spring and leaf spring

Fig -1: CAD model of helical spring

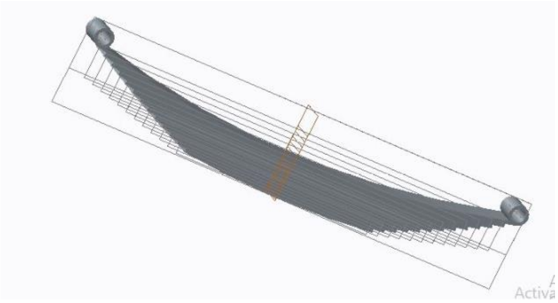


Fig -2: CAD model of Leaf spring

4. Stress analysis of helical spring and Leaf spring using FEM

Solid CAD model of helical spring in .igs format is imported to ANSYS for FEA. Material properties as shown in table 1 are assign and model is meshed using free meshing and smart size option. The FEA model is created are as shown in figure 3 and figure 4.

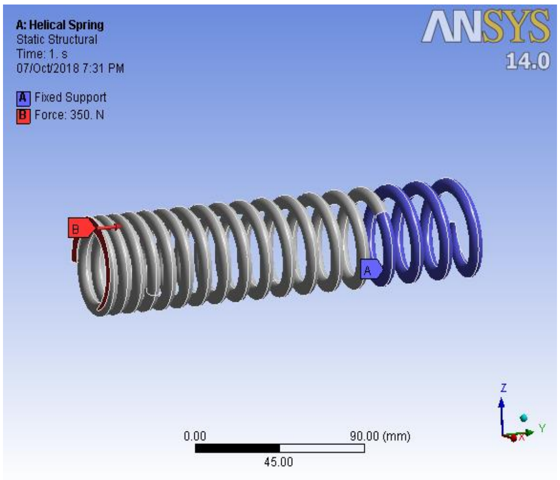


Fig 3: maximum shear stress induced in helical spring.

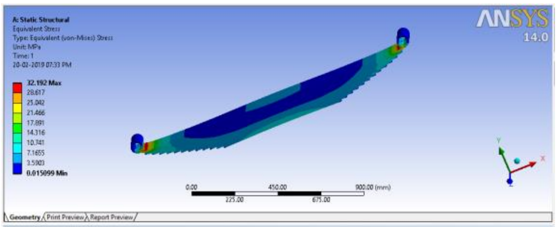


Fig 4: maximum bending stress induced in leaf spring.

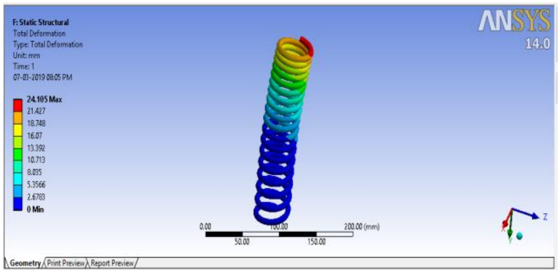


Fig 7: Deformation induced in the helical spring.

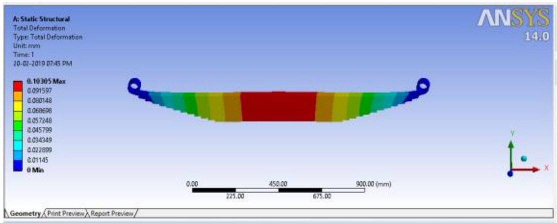


Fig 8 Deformation induced in the Leaf spring.

5. Result discussion and conclusion

The results of stress analysis evaluated from Analytical and FEM for helical spring and Leaf spring presented in table 2 and 3 respectively.

	ANALYTICAL	FEM
Maximum shear stress	141.33 Mpa	127.85 Mpa
Deformation	20 mm	24.10 mm

Table 2: comparison between Analytical and FEA results for Helical spring

The induced stresses obtained from Analytical calculations are compared with FEA results. The results are in close harmony with each other with small percentage of error.

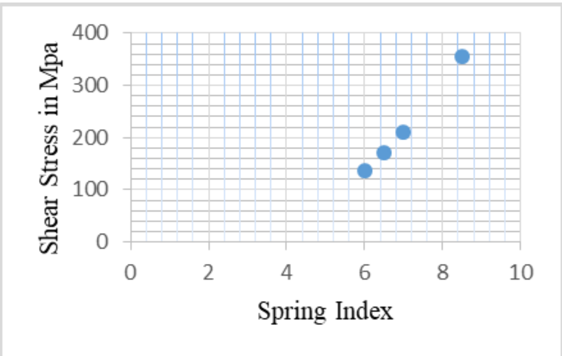
	ANALYTICAL	FEM
Bending Stress	(σ_b)f = 287.5 Mpa (σ_b)g = 190.33 Mpa	σ_b= 295.45 Mpa

Table 3: comparison between Analytical and FEA results for leaf spring

The induced stresses obtained from Analytical calculations are compared with FEA results. The results are in close harmony with each other with small percentage of error.

Spring index (C)	Shear stress (τ) Mpa	Deflection(δ) mm
7.08	212.219	13.268
8.5	355.24	27.51
7.14	156.94	11.66
6.53	169.51	9.632
7.8	169.63	15.52
8.57	182.41	20.15
6.57	146.78	9.08
5.71	131.58	5.97
5	119.13	4
4.28	106.79	2.51
3.57	94.84	1.45
5.31	94.69	4.198
4.72	69.10	2.62
4.47	59.64	2.11
4.25	51.89	1.719

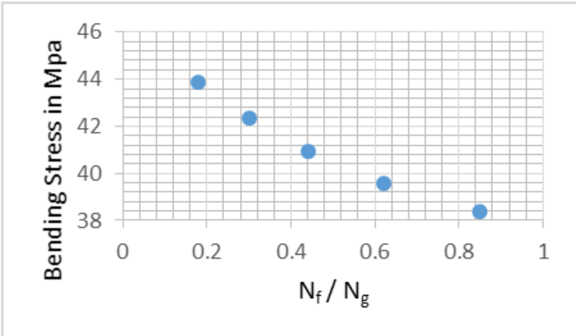
Table 4: The variation of shear stress and deformation in helical spring with spring index



Graph 1: shear stress in Mpa (on y-axis) vs spring index (on x-axis)

$\frac{n_f}{n_g}$	Bending stress (σ_b) In Mpa		Deformation(δ) mm
	Full length leave (σ_b)f	Graduated leaves (σ_b)g	
$\frac{2}{11}$	43.89	29.26	6.79
$\frac{3}{10}$	42.37	28.25	6.56
$\frac{4}{9}$	40.96	27.31	6.34
$\frac{5}{8}$	39.46	26.43	6.13
$\frac{6}{7}$	38.4	25.60	5.94

Table 5: The variation of Bending stress and deformation in leaf spring with ratio ($\frac{Nf}{Ng}$)



Graph2: Bending stress in Mpa vs ratio ($\frac{Nf}{Ng}$)

This study reveals that

1) The results obtained by analytical and FEA are in good agreement with each other.
2) From the graph 5.1 it is seen that as spring index of helical spring increases, shear stress also increases.
3) From the graph 5.2 it is seen that as spring index increases the deflection also increases.
4) From graph 5.3 it is observed that, as $\frac{n_f}{n_g}$ ratio in leaf spring increases the bending stress decreases.
5) From the graph 5.4, it is observed that, as $\frac{n_f}{n_g}$ ratio of leaf spring increases the deflection of the leaf spring decreases.
6) As the free length of helical spring is less than four times the mean diameter of spring coil, there is no chances of buckling of spring.

REFERENCES

1) A text book of machine design R. S. Khurmi and J. K. Gupta
2) Design of machine element V. B. Bhandari
3) Sangmesh Patter, Sanjay S.J, V.B Math [1] "Static analysis of helical compression spring"
4) N.Lavanya, P.Sampath Rao M.Pramod Reddy [2] "Design and analysis of a suspension coil spring for automotive vehicle"
5) P SAIKRISHNA, S VIGNESHWARAN, RAMA RAJU SRINIVASA RAO. [3] "Design and structural analysis of leaf spring using ANSYS"
6) Dev Dutt Dwivedi, V. K. jain P. G. Scholar, Mechanical Engineering, IPS college of Technology Management. [4] "Design and analysis of automobile leaf spring using ANSYS"
7) Design data book for machine elements B. D. Shiwalkar.