Analysis of Helical Conical Spring by CAE tools

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Abstract- Spring is an important mechanical component used in automobile industries and many other applications like as in some types of pen mechanism for writing. In the present study the finite element analysis of helical conical spring is carried out using ANSYS 15 and the material is spring steel according to specification of IS 4454 Grade 3. The simulated results of the present study are compared with the available experimental data from a spring industry. The numerical simulation results for deformation and analytical stress are calculated under various loading conditions. It was found that that the simulated results for deformation and stress shows the good agreement with the available experimental data. In addition to the above analysis a fatigue analysis is also done using analytical method. The spring component which we used for analysis has 500,000 cycle duration. So for safety of spring we will ensure during analysis through analytical method that maximum stress generation in spring should be less than the spring fatigue strength corresponding to their generation cycle.

Keywords- Helical spring, FEM analysis, Stress analysis

I INTRODUCTION

It has been recognized that a metal subjected to repetitive or fluctuating stress will fail at a stress much lower than that required to cause fracture on a single application of load. failures occurring under conditions of dynamic loading are called fatigue failures. so to minimize the fatigue failure or to improve the fatigue strength, various processes is done like heat treatment processes. in the heat treatment processes the material is heated ,holding at that temperature and then cooled by this way the microstructure of material is changed and with it, property of material also changed like the refinement of microstructure in quenched and tempered martensitic steels is expected to improve both strength and toughness especially the latter. lath martensitic structures usually have a higher strength, and improving toughness [11]. The other factor which is investigated to increase the fatigue strength is shot peening. in this case residual compressive stresses are induced in the surface layers. concomitantly, work hardening takes place. also, the accompanying surface roughness may initiate undesirable cracking which may be countered by the residual compressive stresses. however, these stresses can fade during cycling with the surface stress concentrations becoming more dominant than the residual stress field, allowing the fatigue cracks to initiate and subsequently propagate.[12][13][14][15].the surface coating on component is also used to increase the fatigue strength like coating materials deposited onto various substrates have been extensively used in the aerospace, automotive and petrochemical fields, in recent years. basically, micro cracks density in the material of component is related to the high tensile residual internal stresses, hardness and corrosion resistance. it was observed that the residual stresses through-thickness of coating on surface decreases with the depth of the coating. so it is necessary to understand these factors pertaining to the fatigue strength. Luo guiyun et al.[16]in this paper the study was on (no 20) steel. under the study of this paper, that fatigue life of no 20 steel can be increased by doing n ion (nitrogen ion) implementation on no 20 steel. but this implementation process was not an initial process. before it two heat treatment processes had done and that was quenching and normalizing.generally the strength of steel(no 20) is low, it's plasticity property is good and is easy to process, and during the fatigue experiment it was clear that quenching process samples had a good fatigue life result as compare to normalizing process samples. there are basically two stages for fatigue failure which are crack initiation and crack propagation and under this study, the the work was done to improve the strengthening the surface of no 20 steel because if the surface posses the strengthening property then there would be difficult to crack initiation. and this all work was done by the quenching process. James m. boileau and john e. allison[17]:this paper shows the effect of solidification rate and heat treatment processes on property of fatigue life of cast 319 aluminum alloy and this 319 type series has many advantages to the other material as comparison in automotive components because this kind of aluminum alloy series has less in weight property and better mechanical properties.the study of this paper shows that during testing of solidification time condition and heat treated condition on both non hip (hot isostatically pressed) and hip containing porosity and porosity free samples in the t6(" peak aged") or t7("overaged") the results were that, as the solidification time increased the pore diameter in the sample increased and the stress controlled fatigue life decreased. and for the heat treatment process it's more effect was on hip samples for fatigue strength .but for non hip it did not show the significant change for fatigue strength or fatigue life of cast 319 alloy steel.the absence of this influence of heat treatment on non hip samples it can be due to the predominance effect of micro porosity in the samples .which is the cause of fatigue crack initiation in the cast aluminum and this paper showed that for decreasing fatigue strength pore size has more effect as compare to area or volume percentage porosity. somer m. nacy.[18] the study comprises under this research is the effect on fatigue behavior by heat treatment process of (a193-51t-b7) alloy steel. under this study the heat treatment processes quenching, annealing followed by tempering at 200 degree celsius was done to measure the crack length eddy current probe was used and the research result showed that the fatigue crack growth rate in quenching treated specimen and tempering treated specimen is lower than the standard specimen its mean the endurance or fatigue life will increased ,while the fatigue crack growth rate in annealing treated specimen is higher than the standard specimen so its mean the endurance or fatigue limit reduced. according to this study the reduction in fatigue limit of annealing treated specimen is because of formation of soft coarse ferrite grains while in quenching followed tempering treated specimen hard tempered martensite grains formed thus it's lead to increase strength and endurance limit

II. GEOMETRY AND MESH GENERATION

Now for analyzing the spring in ANSYS we will convert it into IGES format and then analysis on spring is done in static structural system of ANSYS 15 edition. The number of nodes in the meshing of spring modeling is 54419 and the number of elements generation is 29093. Under this, the fine mesh generation is selected and then spring will be as shown in figure.1

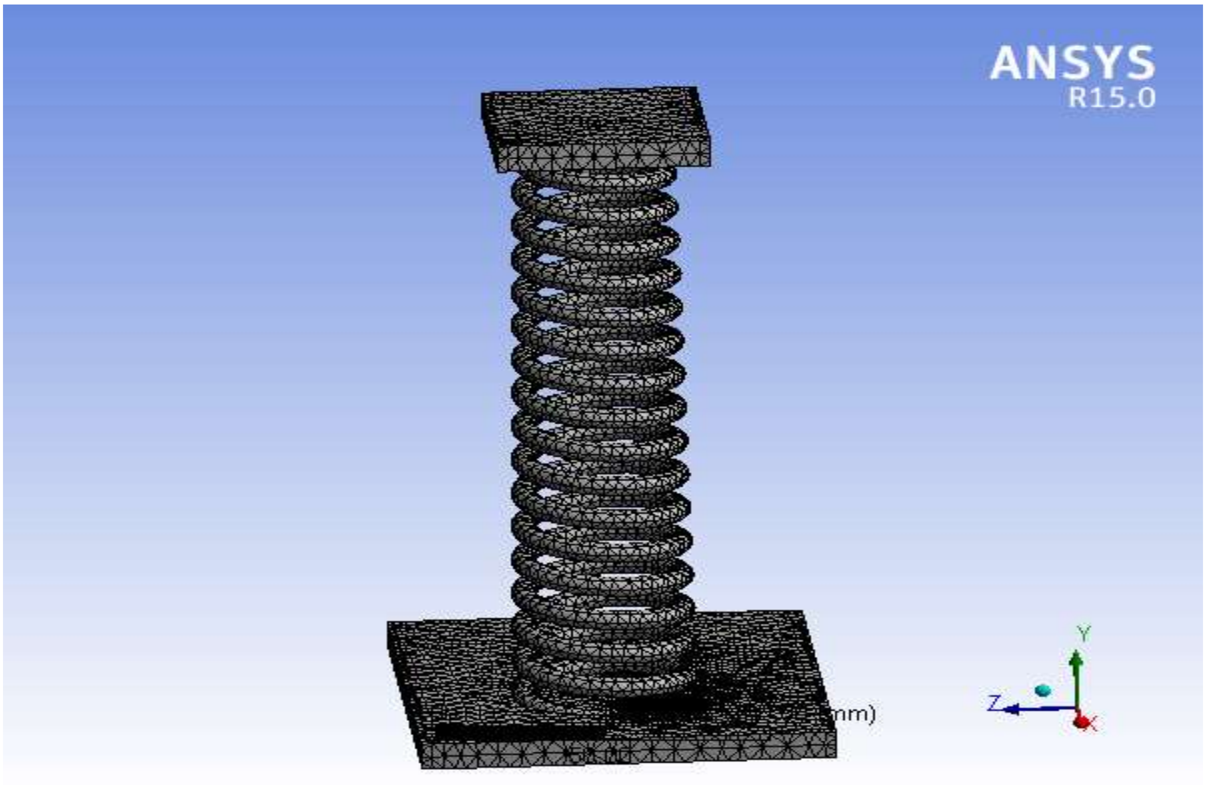

Fig. 1 Schematic diagram of helical Spring

III GENERAL GOVERNING EQUATIONS

Now we find the deflection result by analytical method with the help of deflection formula of conical spring:[2]

$$\delta = \frac{2wn({D_1}^2+{D_2}^2)(D_1+D_2)}{Gd^4}$$

D_1 = small mean coil diameter of spring and D_2 = large mean coil diameter of spring.
δ= deflection of conical spring
W= load applied
d= diameter of wire
n= number of active coil turns
The shear stress formula for spring is:

$$\tau = K\frac{8.W.C}{\pi d^2}$$

"K" is Wahl's stress factor which is :

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

$$C\text{ (spring index)} = \frac{D\text{ mean (larger)}}{d}$$

By solving: The values are C = 6.48 and K = 1.23

IV Boundary condition

In order to simulate the conditions observed in the experiments, the load applied on one end is 372.4 N and second end fixed. Again The load applied on one end is 744.8 N and second end fixed. the maximum deflection we get 37.043.

V RESULTS AND DISCUSSIONS

So by analysis of spring through ANSYS we get results the maximum deflection at a load of 372.4 N we get 18.521 and at 744.8 N, we get a deflection of 37.043. Here we write these results corresponding to their load condition in below given table:
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LOAD (N)	DEFLECTION(mm) by ANYS (FEM method)
372.4	18.521
744.8	37.043

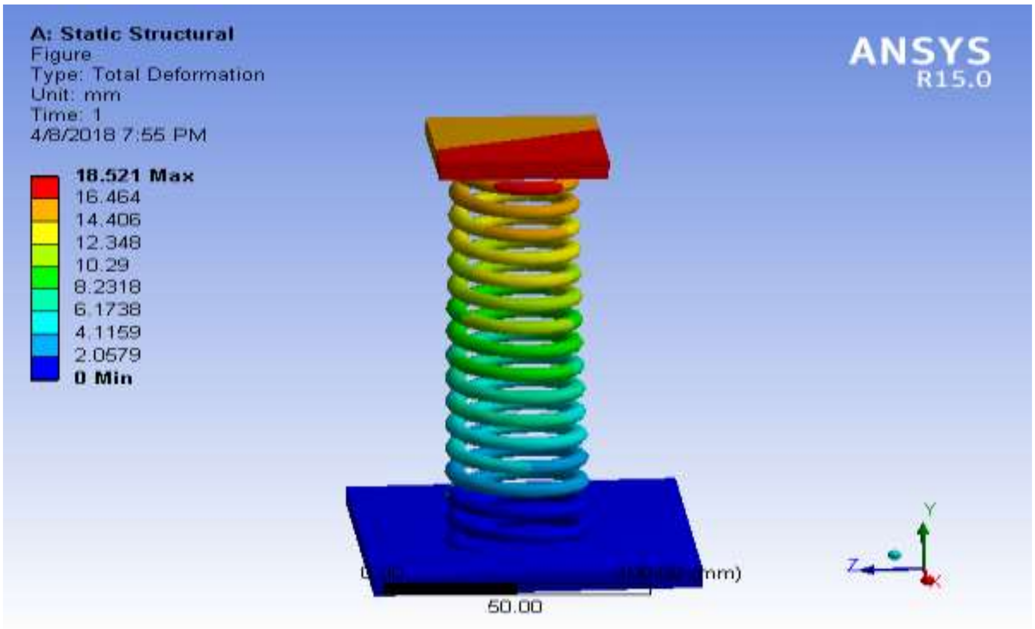

Fig. 2 Deflection of Spring at 372.4 N

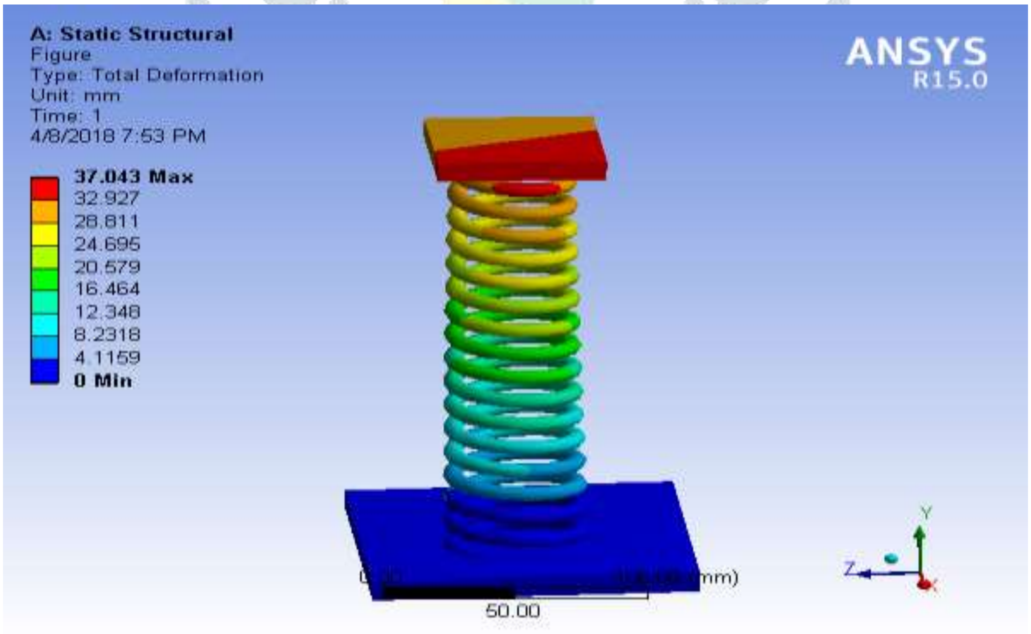

Fig.3 Deflection of Spring at 744.8 N

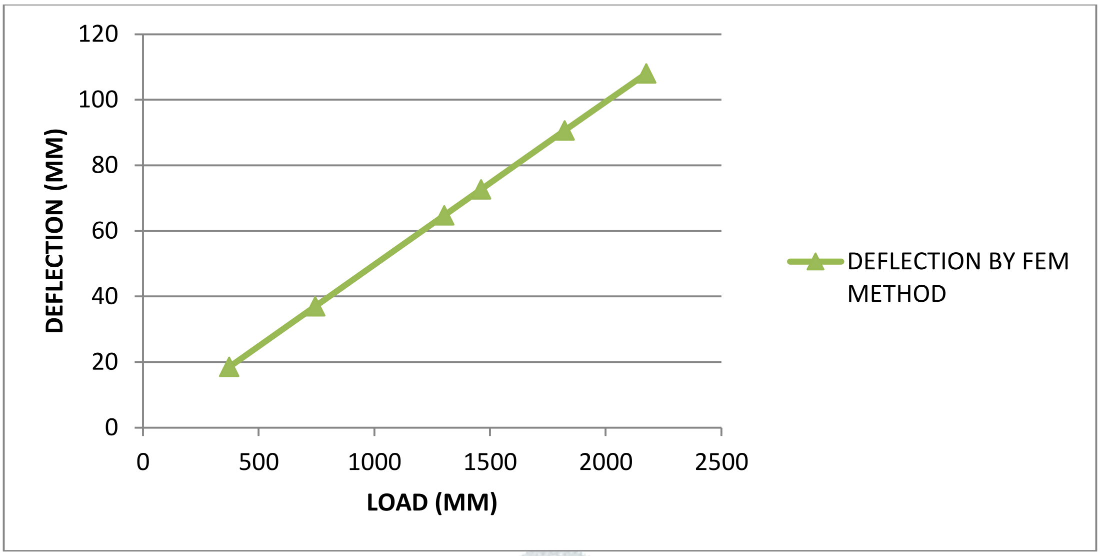

Figure 4. Load Vs Deflection graph

VI CONCLUSION

For future work we can optimize the design of spring by focusing the reason of drastically change in results after 1461.18N by FEM and by considering Properties affection by spring coil diameter, spring wire diameter and also by number of coils of a helical spring

REFERENCES

[1]Singh N. General review of mechanical springs used in Automobiles suspension system. Int. J. Adv. Engg. Res. Studies/III/I/Oct.-Dec. 2013;115:122.

[2] Dasari Ashok Kumar, "Design, Analysis and Comparison between the Conventional Materialswith Composite Material of Leaf Springs," Ph.D dissertation, Dept. Mechanical Engineering.,Univ.JNTU,Kakinada and vijaywada,2016.

[3] Usher AP. A history of mechanical inventions: revised edition. Courier Corporation; 2013 Jul 24.

[4] Paredes M. Analytical and Experimental Study of Conical Telescoping Springs With Nonconstant Pitch. Journal of Mechanical Design. 2013 Sep 1;135(9):094502.

[5] Muñoz-Guijosa JM, Caballero DF, de la Cruz VR, Sanz JL, Echávarri J. Generalized spiral torsion spring model. Mechanism and Machine Theory. 2012 May 1;51:110-30.

[6] White LT. Medieval technology and social change. Oxford University Press; 1962.

[7] Usher AP. A history of mechanical inventions: revised edition. Courier Corporation; 2013 Jul 24.

[8] Dohrn-van Rossum G. History of the hour: Clocks and modern temporal orders. University of Chicago Press; 1996 Jun 15.

[9] Budynas RG, Nisbett JK. Elementos de máquinas de Shigley. AMGH Editora; 2009.

[10] den Boer LJ. Nonlinear dynamic behaviour of a conical spring with top mass (Doctoral dissertation, Master Dissertation, Eindhoven University of Technology, Eindhoven, Netherlands).

[11] Sanij MK, Banadkouki SG, Mashreghi AR, Moshrefifar M. The effect of single and double quenching and tempering heat treatments on the microstructure and mechanical properties of AISI 4140 steel. Materials & Design. 2012 Dec 1;42:339-46.

[12] J.E.Hoffman, D.Lohe, E.Macherauch, Influence of shot peening on the bending fatigue behaviour of notched specimens of Ck 45, in V.Wohlfahrt, H.Kepp, O.Vohringer (Eds). Proceedings ICSP-3, Garmisch-Partenkirchen, DGM Informationsgesellschaft, Verlag, Oberursel, Germany;1987: 631-38

[13] H.Guechichi, L.Castex, Fatigue limits prediction of shot peened materials in International Scientific Conferences on Shot Peening, ICSP-9, Paris, International Scientific Committee for Shot Peening, Mishawaka, Indiana, USA; 2005: 221-28.

[14] D.Eifler, D.Lohe, B.Scholtes, Residual Stresses and Fatigue of Metallic Materials, in V.Hauk, H.Hougardy, E.Macherauch (Eds). Residual Stresses, Measurement, Calculation Evaluation, DGM Informationsgesellschaft, Verlag, Oberursel, Germany; 1991: 157-66.

[15] Wang S, Li Y, Yao M, Wang R. Fatigue limits of shot-peened metals. Journal of Materials Processing Technology. 1998 Jan 1;73(1-3):57-63.

[16] Guiyun L, Guoliang Z, Shiming K, Sixiang W. Improvement of the fatigue lifetime of steel implanted with N after heat treatment. Vacuum. 1989 Jan 1;39(2-4):279-80.

[17] Boileau JM, Allison JE. The effect of solidification time and heat treatment on the fatigue properties of a cast 319 aluminum alloy. Metallurgical and materials transactions A. 2003 Sep 1;34(9):1807-20.

[18] Nacy SM. Effect of Heat Treatment on Fatigue Behavior of (A193-51T-B7) Alloy Steel.