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ANALYSIS OF HOLLOW COIL HELICAL EXTENSION SPRING AND THE STUDY OF OPTIMIZING THE WEIGHT

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ABSTRACT

This paper shows the study which deals with the weight reduction for tensile extension spring by changing the solid spring to hollow one. The springs which are generally used are in solid form due to which the weight of entire body in which the spring is attached gets increased. The forces which can be act on spring may be linear push or linear pull or radial type. This spring deflect by pulling and regain its shape when pulling is neglect. The weight of tensile spring is reduced by changing crossection of tensile spring from solid to hollow crossection and keeping all the other parameters same. For this research, Modeling of hollow and solid tensile spring has been done with the help of CREO2.0. The analytical part of hollow and solid coil spring has been done on HYPERMESH 13.

We conclude the results for two different material viz. SS 304 and ASTM A231and found that the percentage of change in the stresses while comparing the solid spring to the hollow spring for both materials are acceptable. So it is possible to use hollow extension spring in place of solid one, which reduce the weight of the spring and also by which we can reduce the material usage required for manufacturing the spring and the overall cost as well

I. INTRODUCTION

Springs are mainly used in the industry as members absorbing shock energy as well as for restoring the initial position of a part upon displacement for initiating a given function. Extension springs are tightly coiled spring in which the distance between two coils of spring is supposed to be negligible. This spring are tightly wound when there is no load on spring. In this spring the end of the coil is expand because the spring is suffer with greater pulling effect. Extension spring are used to resist pulling or tensile effect, while compression spring are used to resist pushing or compression effect, which means both are used for conflicting to each other work. Extension spring stores the energy and as well as creating a resistance by pulling force. Extension springs have found very wide application in Mechanical engineering field such as weighing machine, Industrial Applications etc[1].

One of the research paper[2], which illustrates the study on weight optimization of helical compression spring. There point of convergence is to reduce the weight of helical compression spring, analysis and testing. Now in this paper comparison between solid and hollow helical extension spring is introduce in terms of mass and stress, moreover material properties of two different material is also used for both solid and hollow. The study of solid shaft, hollow shaft and their comparison from text book[3]

II. METHODOLOGY

In this research work, weight optimization of spring has been done by withdrawing Material from the solid spring i.e. by making the spring hollow. Firstly we calculate all the parameters required for modeling a solid and hollow spring [4] and then it is modeled on CREO2.0.Two different materials *viz. SS 304 and ASTM A231* are used for comparing the change in stresses developed in both solid and hollow spring respectively. Front and top view of spring are shown in figure 1.

Front view *Top view*

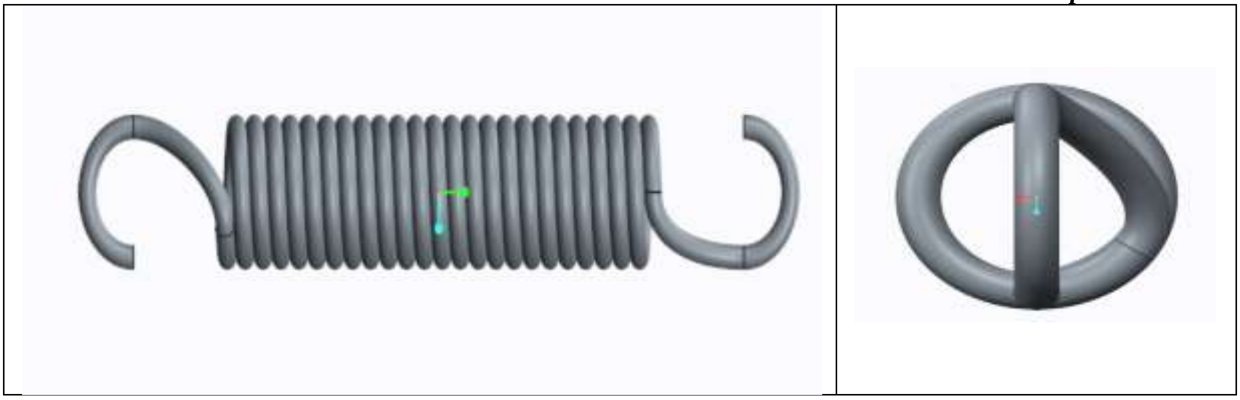

Figure:- 1

Design of spring

Table 1 and table 2 describe the theoretical calculation of solid and hollow spring for SS 304 and ASTM A231 respectively. Which are clearly shows the reduction in weight of both the springs for both the materials.

Table: 1 (SS 304)

Parameter	Solid coil spring	Hollow coil spring
Load applied (P) in N	1200	1200
Coil Diameter in mm	12.5	$d_1 = 12.5, d_2 = 6$
Mean diameter of spring in mm	65	65
Number of coil	24	24
Length inside hook in mm	505	505
Length of hook in mm	102.5	102.5
Deflection (δ) in mm	30.135	31.65
Maximum shear stress (τ) in N/mm^2	132.58	139.605
Weight of coil in Kg	5.005	3.85
Weight reduction	23.03%	

Table: 2 (ASTM A231)

Parameter	Solid coil spring	Hollow coil spring
Load applied (P) in N	1200	1200
Coil Diameter in mm	12.5	$d_1 = 12.5, d_2 = 6$
Mean diameter of spring in mm	65	65
Number of coil	24	24
Length inside hook in mm	505	505
Length of hook in mm	102.5	102.5
Deflection (δ) in mm	27.98	29.27
Maximum shear stress (τ)	142.79N/mm^2	150.95N/mm^2
Weight of coil in Kg	4.87	3.75
Weight reduction	22.99%	

Finite Element Analysis

Firstly design is prepare on CREO and after this CAD model is imported in HYPERMESH 13.0 and the CAD model is subjected to boundary conditions. Designed springs are divided into finite elements by meshing. Tetra mesh and Tria meshing is use for solid and hollow spring respectively; the element size is suppose to be 2.00 in both the case. The meshing of solid and hollow springs are to be shown in figure 2.

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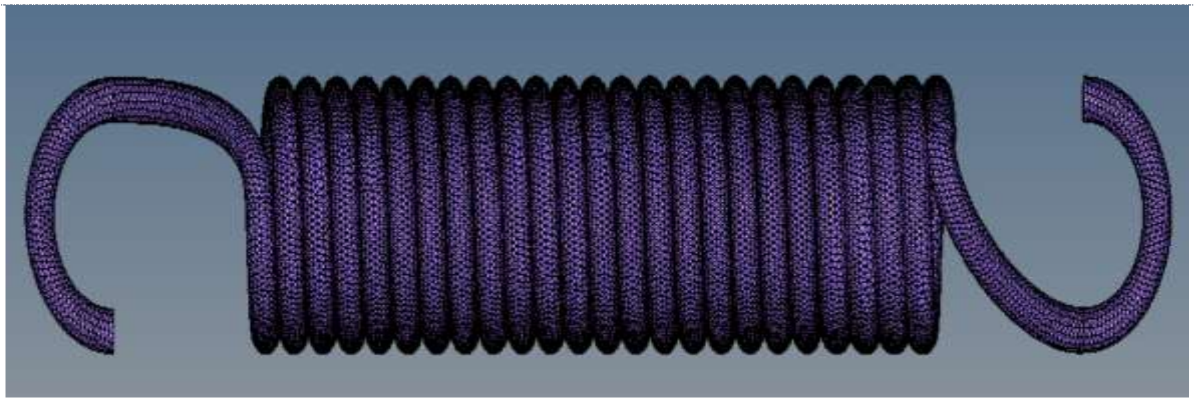

Figure: - 2

Now two different materials SS 304 and ASTM A231 are used. These are following mechanical properties of both materials shown below table 1.

Table:-3 (Mechanical properties)

Name\ Properties	Young modulus(GPa)	Density (Kg/m^3)	Poisson's ratio
SS 304	190	7900	0.265
ASTM A231	200	7800	0.290

Supports and loads

Solid and hollow both spring are subjected into different type of fluctuating loads, loads varies from 600N to 1200N. A fixed support is attached on the another side of springs while the loads are action on opposite side of fixed support, which is shown in figure 3.

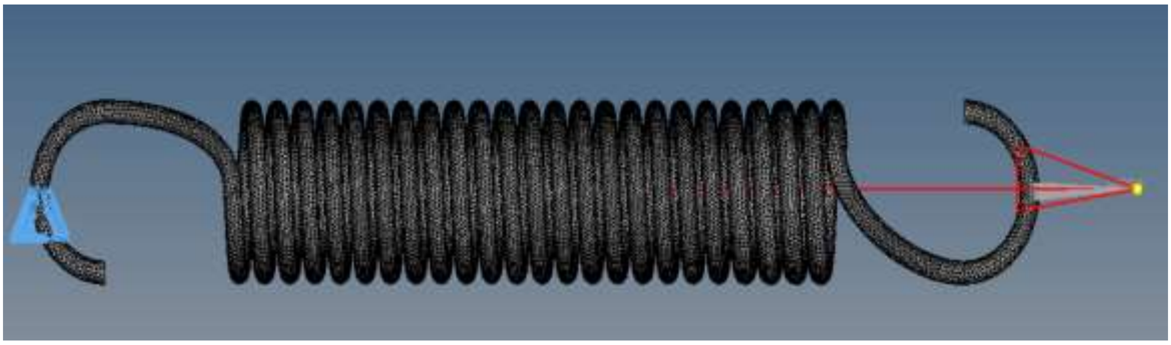

Figure:-3

On the loading side firstly make another component named Rbe3. In this component one node is created on some distance and other nodes of spring which comes under in loading are connected to that one node, means a load is equally distributed on every node. Now creating a load step by which fix and load are define into the HYPER WORKS.

Figure 4 shows the vonmises stress of solid extension spring whose material is ASTM A231. Maximum vonmises stress develop in a spring is 387.6N/mm^2 while subjected on load of 1200N.

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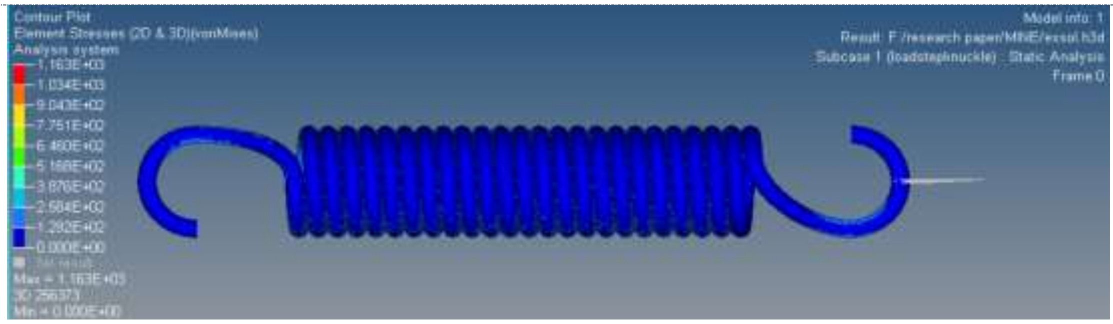


Figure:-4

Figure 5 shows the vonmises stress of hollow extension spring whose material is ASTM A231. Maximum vonmises stress develop in a spring is 336.2N/mm^2 while subjected on load of 1200N.

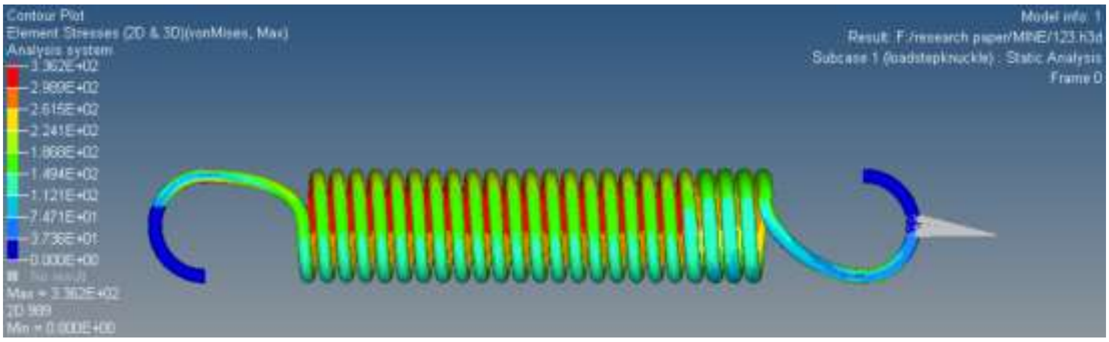
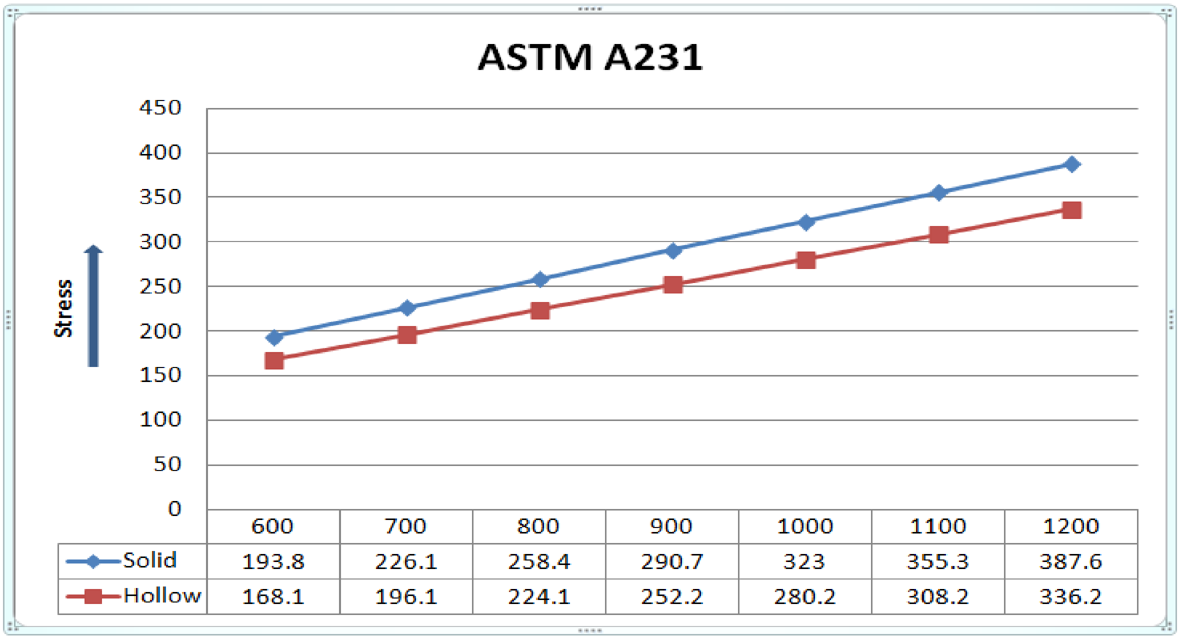


Figure:- 5

Graph 1 shows the comparison between solid and hollow coil extension spring whose material is ASTM A231, moreover it also shows the chart of different vonmises stress while subjected on different types of load. It varies from 600N to 1200N.



	600	700	800	900	1000	1100	1200
Solid	193.8	226.1	258.4	290.7	323	355.3	387.6
Hollow	168.1	196.1	224.1	252.2	280.2	308.2	336.2

Graph :-1

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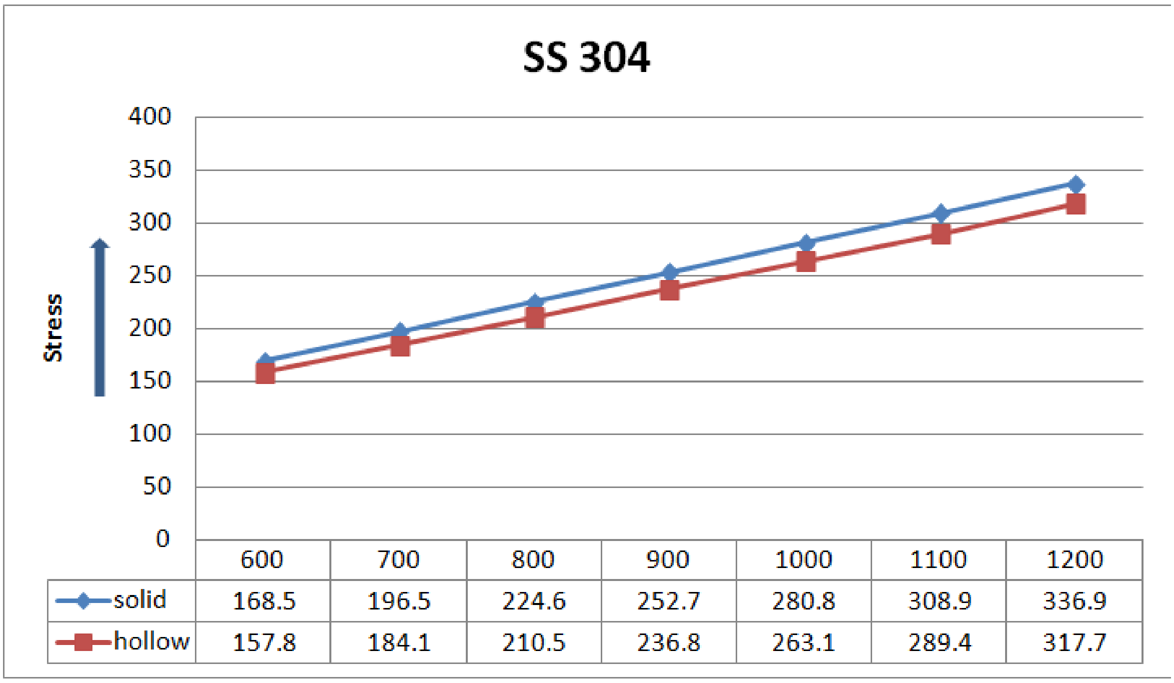
Graph 2 shows the comparison between solid and hollow coil extension spring whose material is SS 304, moreover it also shows the chart of different vonmises stress while subjected on different types of load. It varies from 600N to 1200N.



Graph:-2

Figure 6 shows the vonmises stress of hollow extension spring whose material is SS 304. Maximum vonmises stress develop in a spring is 317.7N/mm^2 while subjected on load of 1200N.

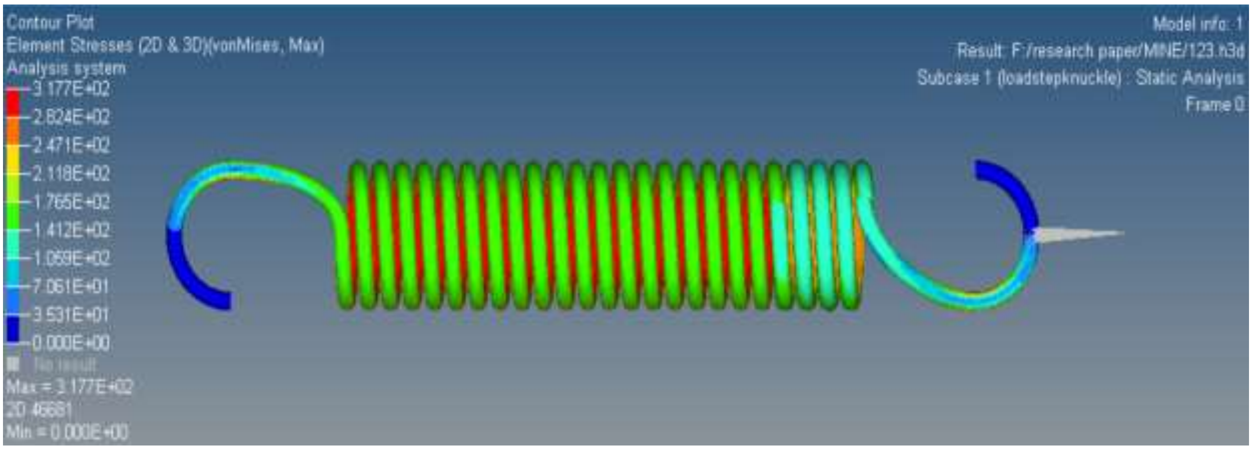


Figure:-6

As we know From figure 5 and figure 6 shows the vonmises stress of ASTM A231 and SS 304 respectively of hollow coil extension spring. Graph 3 illustrates the comparison between hollow spring of both material.

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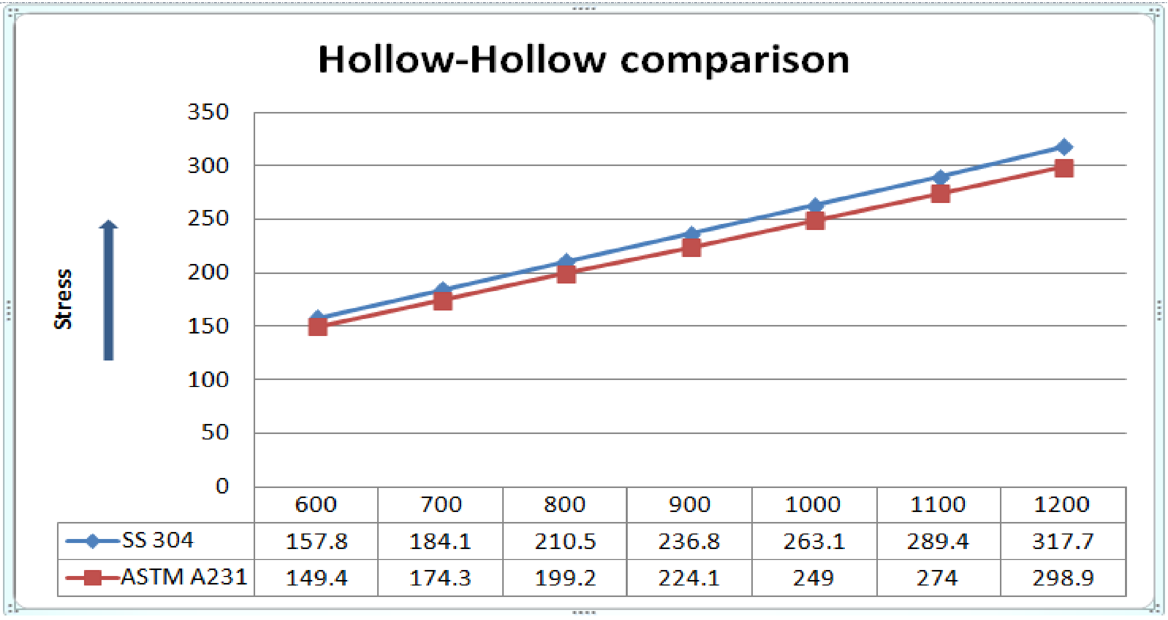

Graph:- 3

III. COMPARISON OF RESULT

In table 1 we calculate the weight reduction between solid and hollow is 23.03% for SS 304 and change in deflection is 4.7%.

In table 2 we calculate the weight reduction between solid and hollow is 22.9% for ASTM A231 and change in deflection is 4.4%.

From graph 1 we observed that the vonmises stress of solid is little more than hollow coil extension spring and the change in vonmises stress of solid and hollow coil extension spring for ASTM A231 is 13.25% which is in permissible limit. In case of hollow coil spring analysis by HYPER WORKS variation less than 15% is acceptable.

From graph 2 we observed that the change in the vonmises stress of solid and hollow coil extension spring for SS 304 is only approx 6% which is in permissible limit.

From graph 3 we observed that the change in percentage vonmises stress in SS 304(6%) is less than percentage vonmises stress in ASTM A231(13.26%), hence if we have choices for choosing material SS 304 is superior than ASTM A231.

IV. CONCLUSION

This study is basically concentrate on weight optimization of extension spring and comparison of von misses stress developed in hollow and solid coil extension spring for two different material SS 304 and ASTM A231.
From this study we found that we can use hollow coil extension spring in a place of solid coil extension spring because the change is only 6% in vonmises stress for SS304. We also found that the change in vonmises stress is 13.25% for ASTM A231 nevertheless we can use hollow coil in place of solid coil, moreover weight is also reduce

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