Design and Analysis of Wave Spring

Ravindra A. Kshirsagar[#1], Sandesh S. Gaonkar[#2], Somnath M. Pandharpure[#3], Dipanjali Desale[#4], Shubhada K Gorave[#5]
[#]Mechanical Engineering, Sinhgad Institute of Technology and Science Narhe, Pune ,India

Abstract - **The Spring which is one of the parts of suspension system, which is structured mechanically to deal with shock impulse and dissipate kinetic energy. It decreases the amplitude of disturbances leading to increase in comfort and enhanced rider quality. Multi-turn wave spring can possibly replace the conventional coil spring in a variety of applications by providing the same effect and deflection characteristics and utilizing half of the space. The helical compression spring utilized in suspension systems. Wave springs are more minimized than coil springs and are adoptable for assembling utilizing composite spring. The utilization of composites for the wave spring represents significant challenges is not only understanding the elastic response, but also the failure and fatigue characteristics. So it is important to plan composite wave springs with the goal that we can think about whether the wave spring demonstrates excellent reputations and robust fatigue behavior or not. Also, endeavor to think about the outcomes for choosing the best materials for the spring will be finished.**

Keywords—composite wave spring; wave spring; design of wave spring; modeling of wave spring; wave spring analysis.

I. INTRODUCTION

The spring which is one of the part of suspension system, which is planned mechanically to deal with handle shock impulse and dissipate kinetic energy. Among the numerous sorts of springs, wave springs have impressive consideration this kind of long and reliable source of long lasting durability. A wave spring is typically a coil spring that opposes body vibrations and impact forces. It is normally developed out of a coil shaped piece of steel that interfaces with body at two points, and at the left and right sides of the suspension e.g. valves in industries. Among numerous kinds of springs, wave spring have pulled in extensive attention. Because of the specific shape of spring in the unreformed design, the straight considerable load and deflection curve is obtained. Also load and internal stress, relationship are also analysed and final analytical results are comparable with theoretical analysis to correlate well with trial measurements. The extraordinary arrangement on trial deals on spring failure analysis of automotive suspension. Fatigue and dynamic loading is to be done result of very high cycle fatigue taste on helical compression spring as well as wave springs. So it is inportant to study FEA of wave as well as helical spring so as to obtained the relatively sustainable outcome. Before designing the composite wave spring, there is a investigation of helical coil spring of material IS 4454 whose static analysis is done using finite element method and results showing detailed load and deflection of springs are noted.

A. Problem statement

To design and analyse a composite wave spring which will likely to be work more accurately than that of helical coil spring. But before this, we need to study helical coil spring and also other traditional springs used in different applications .This study is more helpful in analysing wave spring, and also we can compare the results of helical springs and can make a conclusion.

B. Methodology

According to the problem statement i.e. to check whether composite wave springs has potential information about theoretical formulae, different applications is done where to replace helical springs or not .A collection of all the springs can be used, total assumptions and boundary conditions required for simulation purpose.

II.LITERATURE REVIEW

H.R. Erfanian-Naziftoosi et al. proposed that Multi-turn wave springs have potential to replace conventional coil springs providing the same force and deflection characteristics using only half the space. Also studied mechanical behaviour of the composites for the wave springs represents significant challenges is not only understanding the elastic response, but also the failure and fatigue characteristics. In this paper, wave spring is studied using experimental, analytical and numerical approaches. Quasi-static and fatigue experiment performed on the composite wave spring demonstrating excellent repeatability and robust fatigue behaviour.[1]

H.B. Pawar et al. designed the helical compression spring used in suspension system or shock absorber for smoothing out or damping shocks and dissipate kinetic energy .A helical compression coil spring which is used in transport three wheeler which is belonging to Indian automotive market. He observed that, the vehicle drifts towards one side due to high weight of suspension system . This problem can be solved by redesigning and optimizing front suspension spring. For the present study the IS4454 material was taken for consideration. Optimization of spring was done by reducing total number of turns and prototypes of the spring were made. The static analysis using finite element method has been done. In ordered to find out the detailed load verses deflection of spring.[2]

P. N. L. Pavani et al. proposed that conventional compression springs are not as precise as wave spring that can not fit into assemblies. The overall length and operating heights of springs are lower than those of conventional round wire spring, they will often reduce the size of assembly as much as 50%. Off course, this will also reduce the part weight and raw material cost of every spring produced[3].

Wave spring operates as load bearing devices . They take up play and compensate for dimensional variations within assemblies. In this paper, structural analysis has been conducted on the wave spring by varying the spring material such as Structural steel and Beryllium Copper. For this analysis loads are considered as bike weights, single person and two persons. Structural analysis is done to validate the strength. This study makes an attempt to compare the reasons for selecting best material for spring.[3]

N. Tang et al. investigates vibration suppression for a novel frictional system –a wave spring two different types of wave springs, crest to crest and nexted once, where used in this work. Compared with nested wave spring crest to crest wave spring have lower damping and a larger range for the linear stiffness due to reduced level of contact. Dynamic compressive tests, subjected to different static compression level, are carried out to investigate the forced-displacement hysteresis of individual wave spring. The stiffness is shown to increase upto 800% when the static compression is 40%. The crest to crest wave spring is to provide loss factors upto 0.12 while nested once as high as 0.80. Testing also show that the performance did not degrade between room temperature and 100 celcius. The effect of different spring materials, inner diameter and flat spring width are also evaluate.[4]

III. SELECTION OF MATERIALS

Table 1. Properties of material

Parameter/Material	**Stainless Steel 302**	**Beryllium Copper**	**Structural Steel (Mild Steel)**
Young's Modulus E (psi)	$28*10^6$	$18*10^6$	$31.91*10^6$
Shear Modulus G (psi)	$10*10^6$	$7.25*10^6$	$11.85*10^6$
Density lb/in^3	0.286	0.298	0.284
Ultimate Strength (psi)	$1.247*10^5$	$21.5*10^4$	$50.04*10^3$
Yield Strength (psi)	$7.54*10^4$	$17.48*10^4$	$30.02*10^3$
Poisson's Ratio	0.3	0.3	0.3

IV.DESIGN AND ANALYSIS

A.Modeling dimensions of the springs

Table 1. Diamensions of material

Parameters	**Helical spring(mm)**	**Wave spring(mm)**
Outer diameter	72	72
Inner diameter	52	48
Mean Diameter	62	60
Free length	250	175
No. of turns/plates	10	10

B. Modeling of the Spring

Modeling of the helical and wave spring is done using Autodesk Inventor 2016 modeling software as shown in fig.1 (a) and (b).

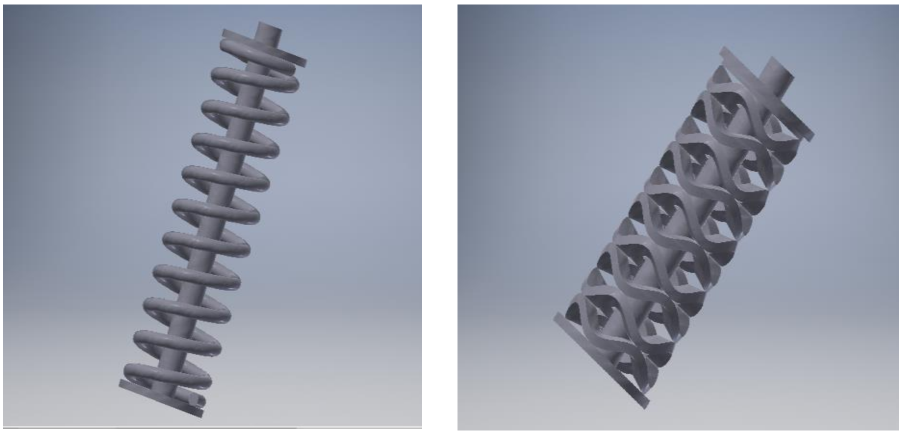

Fig.1.Modeling of (a) Helical spring; (b) Wave spring

V. ANALYSIS OF HELICAL AND WAVE SPRING

Analysis is done by varying the loads .In analysis is to determine the deflections of structure during different load conditions. Obtained deflections are as shown in fig.2

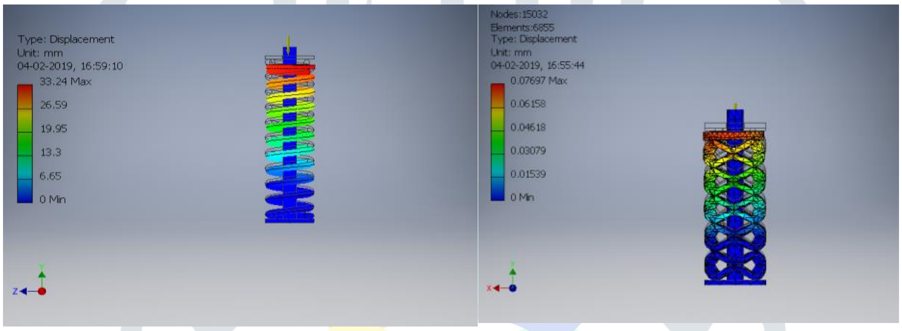

Fig 2.Deflection of Structural steel (a) Helical spring (b) Wave spring when the load is 125kg

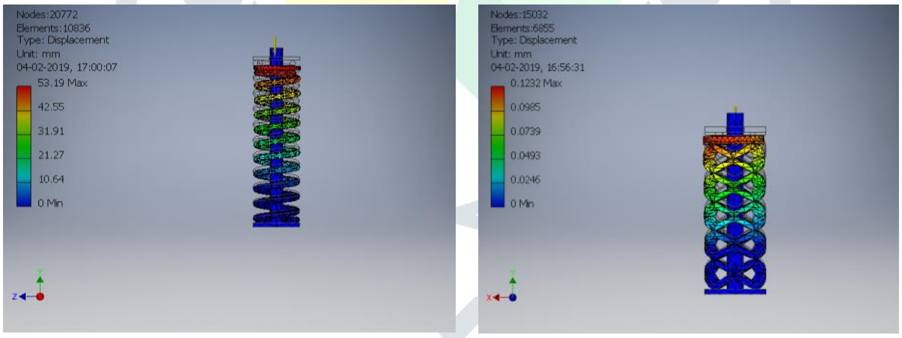

Fig 3. Deflection of Structural steel (a) Helical spring (b) Wave spring when the load is 200kg

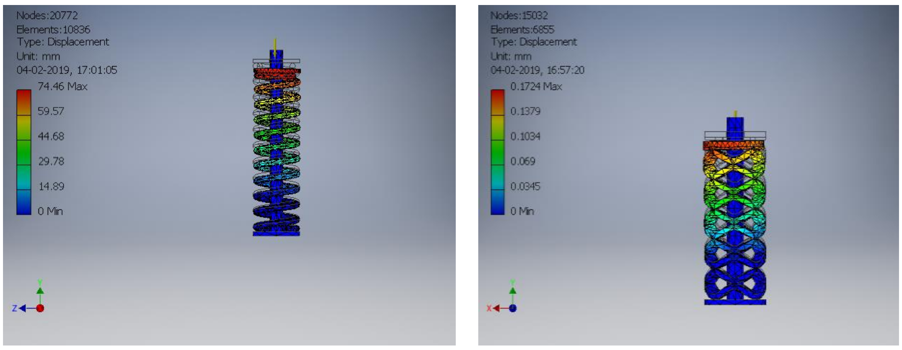

Fig 4. Deflection of Structural steel (a) Helical spring (b) Wave spring when the load is 280kg

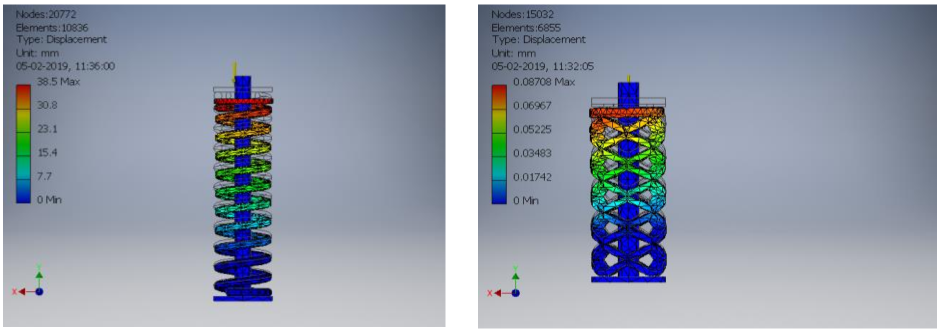

Fig 5. Deflection of Stainless steel (a) Helical spring (b) Wave spring when the load is 125kg

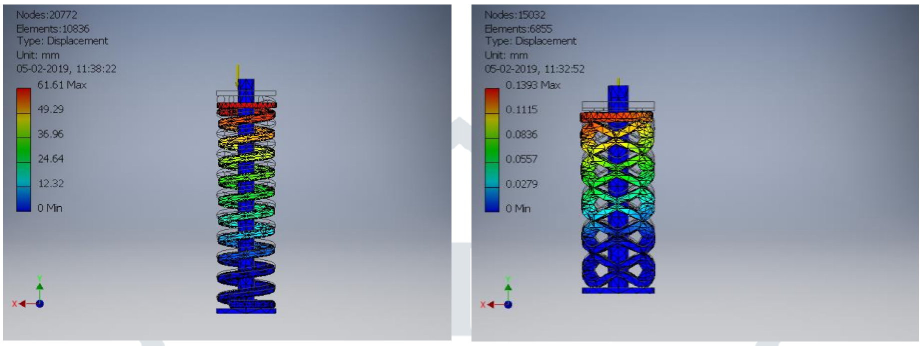

Fig 6. Deflection of Stainless steel (a) Helical spring (b) Wave spring when the load is 200kg

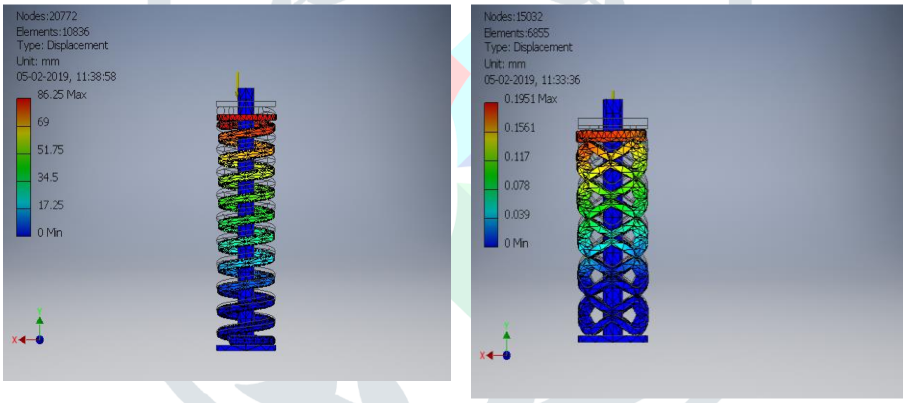

Fig 7. Deflection of Stainless steel (a) Helical spring (b) Wave spring when the load is 280kg

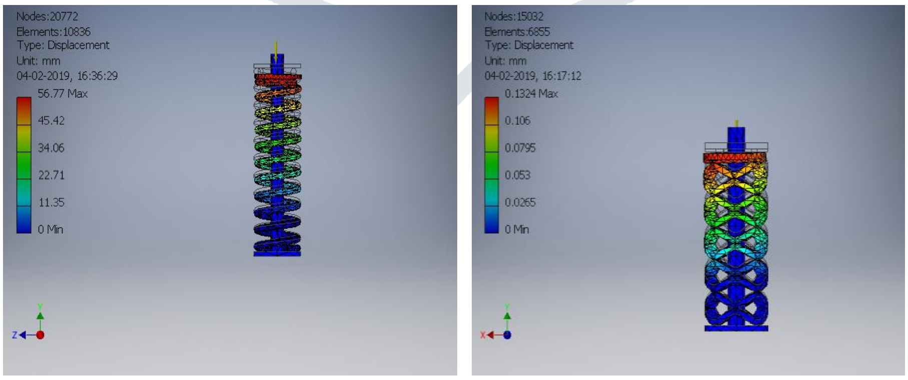

Fig 8. Deflection of Beryllium Copper (a) Helical spring (b) Wave spring when the load is 125kg

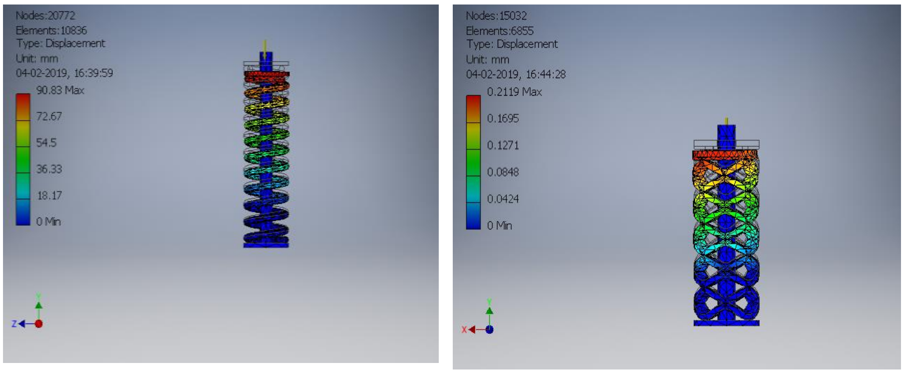

Fig 9. Deflection of Beryllium Copper (a) Helical spring (b) Wave spring when the load is 200kg

VI. RESULT AND DISCUSSIONS

The finite element analysis has been carried out for helical and wave spring by considering Stainless steel ,Beryllium copper and Structural steel as spring material and the results were compared as shown in table. From the above analysis it was concluded that as wave spring under goes less deflection than that of helical springs. Both springs were analyzed and compared at different loads and for different materials

Table 3. Deflection of helical and wave spring

Materials	**Load,kg**	**Deflection for helical spring (mm)**	**Deflection for wave spring (mm)**
Stainless Steel 302	125	38.5	0.08708
	200	61.61	0.1393
	280	86.25	0.1951
Beryllium Copper	125	56.77	0.1324
	200	90.83	0.2119
	280	127.2	0.2967
Structural Steel	125	33.24	0.07697
	200	53.19	0.1232
	280	74.46	0.1727

VII. CONCLUSIONS:

By performing static analysis comparison of wave spring with helical spring is done . Results shows that wave spring possess less deflection when compared with the helical spring . So it is more convenient to use wave spring in automobile sector. From above results it is concluded that wave spring is suitable for more than 280 kg load.

REFERENCES

[1] H. R. Erfanian-Naziftoosi, Seyedmohammad S. Shams, Rani Elhajjar, "Composite Wave Spring : Theory And Design", Elsevier, Materials and Design, Volume 95, 2016, pp. 48-53.

[2] H. B. Pawar, D. D. Desale, "Optimization of Three Wheeler Front Suspension Coil Spring", Science Direct, Manufacturing, Volume 20, 2018, pp.428-433

[3] P. N. L. Pavani, B. K. Prafulla, R. Pola Rao, S. Srikiran, "Design, Modeling and Stuctural Analysis of Wave Spring",Science Direct, Material Science, Volume 6, 2014, pp. 988-995.

[4] N. Tang, C. E. Lord, N. D. Sims and J. A. Rongong,"Experimental Investigation and Modeling of Dynamic Performance of Wave Springs", The University of Sheffield, Volume 3, 05-07 Sep. 2016, pp.402-418