Effect of waves in wave spring

Hardik C. Tekwani[1]

[1]Assistant Professor, Mechanical Eng. Dept., VIE Kotambi, Gujarat, INDIA

ABSTRACT

Wave springs are precise flat wire compression springs that fit into assemblies that other springs cannot since the overall lengths and operating heights of Wave springs are lower than those of conventional round Wire springs, they will often reduce the size of an assembly by as much as 50%. Of course, this will also reduce the part weight and raw material cost of every spring produced. Wave springs operate as load bearing devices. In paper what are the effects of wave in performance of wave spring is proposed. The present study makes an attempt to compare the results for selecting best material for springs.

Keyword: - *helical spring, wave spring, wave, working height, stress, deflection, frequency etc.*

---

1. INTRODUCTION

Among the many types of springs, wave springs have attracted considerable attention this kind of long and reliable source of long lasting durability and considerable effectiveness than rest of the springs (David Clarke, 2002). An analytical model for stamped ring wave springs is proposed, Because of the particular shape of the spring in the unreformed configuration, the load—deflection curve is found to be appreciably bilinear in character. A similar but less pronounced behavior is displayed also by the relationship between load and internal stresses. The analytical results are compared to earlier theoretical findings and are shown to correlate well with experimental measurements [1].

Wave springs are used to reduce the height of the spring and to produce the same end effect end that of a coilspring .these were first developed by SMALLEY Industries U.S.A in 1990's. These also obey the principles ofHooke's law discovered by Robert Hooke (Ulf Kletzin, 2007). So on taking the above basis wave spring application on suspension system is made. Suspension is the term given to the system of springs, shockabsorbers and linkages that connects a vehicle to its wheels and allows relative motion between the two(J.Mayor,1965). In general coil springs were used as a suspension system in the form shock absorber in 1901 by Mors automobile factory, France. A suspension system or a shock absorber is the mechanical device designed to smooth out or damp shock impulse and dissipate kinetic energy, in a vehicle it reduces effect of travelling over a rough road leading to improved ride quality (P.P.Mohan, 2005).A sustainable development of dynamic finite element program must develop on helical springs and structural analysis should also be done in precise (Doojong Kim 1999) [2].

1.1 Helical Spring:

The primary elastic members of suspension system are helical compression springs that connect the wheel to body and store the energy, absorb the shock due to road irregularities and transmitted to the body [3]. Fatigue failure is caused due to dynamic loading in suspension system in different ways. The inner surface of active coil is under maximum stress and coil surface is vulnerable to imperfections of material that causes stress concentration at various points which initiates the fatigue cracking. Helical springs can be classified, considering loads as helical compression, tension and torsion spring.

1.2 Wave spring:

Among the many types of springs, wave springs have attracted considerable attention this kind of long and reliable source of long lasting durability and considerable effectiveness than rest of the springs. Wave springs are used to reduce the height of the spring and to produce the same end effect end that of a coil spring.

Wave springs operate as load bearing devices. They take up play and compensate for dimensional variations within assemblies. A virtually unlimited range of forces can be produced whereby loads build either gradually or abruptly to reach a predetermined working height. This establishes a precise spring rate in which load is proportional to deflection.

Functional requirements are necessary for both dynamic and static spring applications. Special performance characteristics are individually built into each spring to satisfy a variety of precise operating conditions. Typically, a wave spring will occupy an extremely small area for the amount of work it performs. The use of this product is demanded, but not limited to tight axial and radial space constraints.

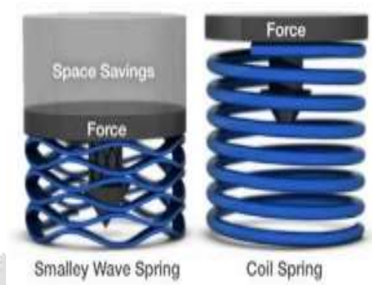

Fig. 1 Model of wave spring and hellical spring

2. METHODOLOGY

2.1 Deflection and operating stress in wave spring

Nomenclature

b = Radial Wall, in. [(O.D. - I.D.) ÷ 2]
Dm = Mean Diameter, in. [(O.D. + I.D.) ÷ 2]
E = Modulus of Elasticity (psi)
f = Deflection (in.)
H = Free height (in.)
I.D. = Inside Diameter (in.)
K = Multiple Wave Factor
L = Length, overall Linear (in.)
N = Number of Waves (per turn)
O.D. = Outside Diameter (in.)
P = Load (lb.)
S = Operating Stress (psi)
t = Thickness of Material (in.)
W.H. = Work Height (in.) [H-f]
Z = Number of Turns

N	2.0 - 4.0	4.5 - 6.5	7.0-9.5	10.0+
K	3.88	2.9	2.3	2.13

Table-1: value of K corosponding to N

Deflection = f $= \frac{PKD_m{}^3 Z}{Ebt^3N^4} \frac{I.D.}{O.D.}$

Operating stress = S = $\frac{3\pi PD_m}{4bt^2N^2}$

P	K	ID	OD	D_m	Z	b	t	N	E	f	S
600	3.88	3.937	4.7244	4.3307	20	0.3937	0.1181	2.5	29007548	4.288643	178391.8019
600	2.9	3.937	4.7244	4.3307	20	0.3937	0.1181	4.5	29007548	0.305349	55059.19812
600	2.3	3.937	4.7244	4.3307	20	0.3937	0.1181	7.5	29007548	0.31386	19821.21132
600	2.13	3.937	4.7244	4.3307	20	0.3937	0.1181	10.5	29007548	0.007566	10112.91394

Table-2: calculation for 600lbs

P	K	ID	OD	D_m	Z	b	t	N	E	f	S
1000	3.88	3.937	4.7244	4.3307	20	0.3937	0.1181	2.5	29007548	7.147737916	297319.6698
1000	2.9	3.937	4.7244	4.3307	20	0.3937	0.1181	4.5	29007548	0.508914555	91765.33019
1000	2.3	3.937	4.7244	4.3307	20	0.3937	0.1181	7.5	29007548	0.052309397	33035.51887
1000	2.13	3.937	4.7244	4.3307	20	0.3937	0.1181	10.5	29007548	0.012610123	16854.85657

Table-3: calculaion for 1000 lbs

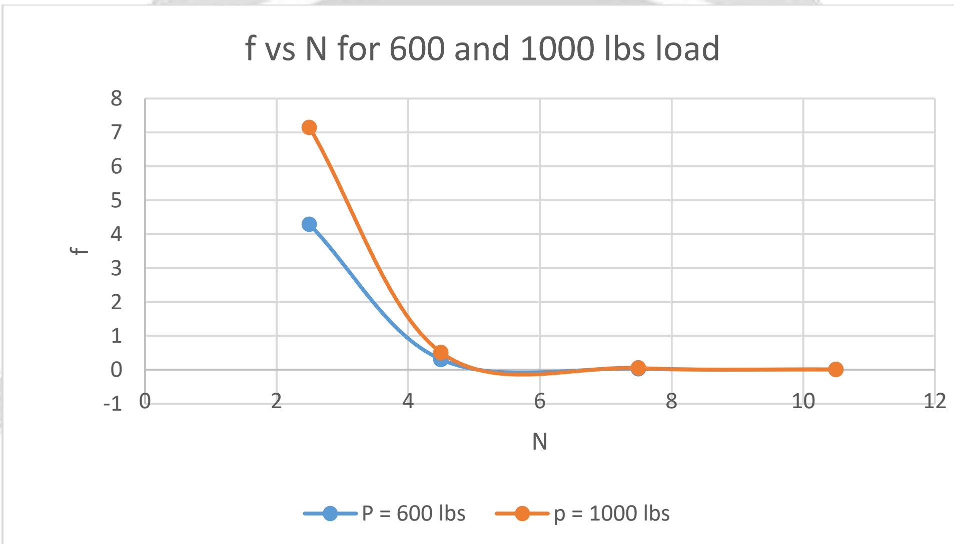

Chart-1 : f Vs N for 600 and 1000lbs

2.2 Deflection and operating stress in helical spring

Helical spring: Parameters:
- Mean Diameter of coil (D)
- Wire diameter (d)
- Number of active coils (z)
- Coil free height (h)
- Pitch (P)
- Spring index (C)
- Modulus of Rigidity (G)
- Spring Index (C)
- Shear Stress factor (k)
- Maximum shear stress (τ) $=\frac{8KwC}{\pi d^2}$
- Deflection (δ) = $\frac{8wnD^3}{Gd^4}$

w	G	d	D	z	f	τ
600	11501493	0.3937	4.3307	15	21.16367	9857.366
600	11501493	0.3937	4.3307	20	28.21822	9857.366
600	11501493	0.3937	4.3307	25	35.27278	9857.366
600	11501493	0.3937	4.3307	30	42.32734	9857.366

Table-4: calculaion for 1000 lbs

w	G	d	D	z	f	τ
1000	11501493	0.3937	4.3307	15	35.27278	16428.94
1000	11501493	0.3937	4.3307	20	47.03037	16428.94
1000	11501493	0.3937	4.3307	25	58.78797	16428.94
1000	11501493	0.3937	4.3307	30	70.54556	16428.94

Table-5: calculaion for 1000 lbs

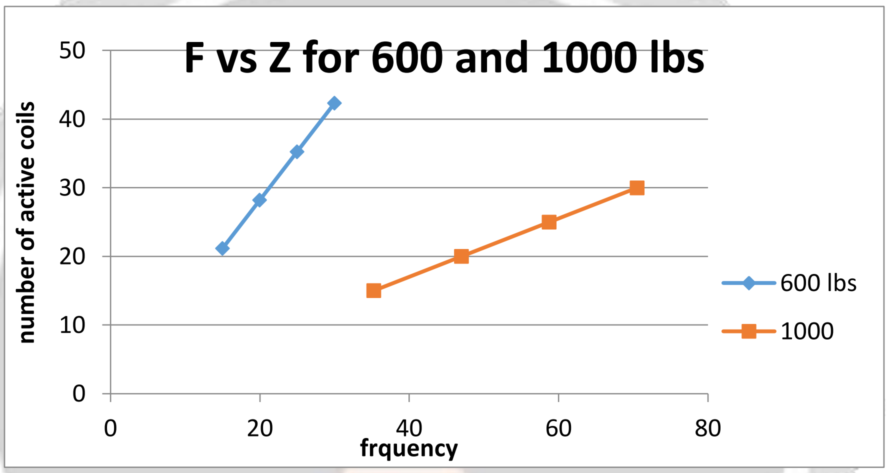

Chart-2 : f Vs N for 600 and 1000 lbs

3. CONCLUSIONS

- For the wave spring calculation conclude that as the wave increase the frequency of the spring will decrease and also chart shows the frequency versus wave of spring for two different load. Here rapid decrement of frequency from 1000lbs to 600 lbs.
- For the helical spring, frequency versus no. of active coil chart shows that as the no. of active coil decrease frequency also decrease.
- Future scope: other analysis also carried out for deferent application andstatic and dynamic analysis can be done for different waves of spring and their effects and stress generation.

4. REFERENCES

[1] E. Dragoni, July 1, 1988, A Contribution to Wave spring, The Journal of Strain Analysis for Engineering Design, vol. 23 no. 3 pp.145-153

[2] P.P.Mohan, T.L.Kishore, Dec, 2012, Design and analysis of a shock absorber, International Journal of Engineering Research and Technology, vol.1, issue 4, pp. 578-592

[3] Youli Zhu *, Yanli Wang, Yuanlin Huang. Failure analysis of a helical compression spring for a heavy vehicle's suspension system, CC BY-NC-ND, Published by Elsevier Ltd.

[4] http://www.smalley.com/spring-design/multiple-turn