Study & Calculation of Wave Spring

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Abstract- *Springs are flexible machine components which is used for controlled application of force or for storage and discharge of mechanical energy. Normally, a wave spring will occupy an externally small area for the amount of work it performs. The present study makes an attempt to compare the results the use of wave spring.*

Keywords- Suspension system, Suspension system, Wave spring, Design.

I. INTRODUCTION

Nowadays the vehicle design are getting compact and the comfort of the vehicle is a very important topic because things are getting unconventional day by day and the suspension system are also getting more and more advanced so the parts used in the suspension system should be also updated and thus to recreate new form of springs the crest to crest wave springs technology has led an exceptional lead in the new form of springs that acquire less space and give the same outcome so its efficiency increases a lot.

A wave" spring is made in which linear relation is engaged between a load and a deflection. Thereby, the degree of freedom of design of springs is improved.

A wave spring, also identified as coiled wave spring or scrowave spring, is a spring made up of pre-hardened flat wire in a process called on-edge coiling (also known as edge-winding). Through this procedure, waves are added to give it a spring effect. The number of turns and waves can be simply adjusted to accommodate stronger force or meet specific requirements

1.1 AIMS AND OBJECTIVES OF WAVE SPRINGS SHOCK ABSORBERS

Wave springs shock absorbers systems have four general goals:

- The wave springs obtain less space than the conventional coil springs.
- The wave springs absorb more jerks than the conventional coil springs
- They are more effective in terms of work done with respect to its size
- The flat coil wave springs needs less material surface diameter correspondingly.

1.2 DRAWBACKS OF CONVENTIONAL COIL SPRINGS

The conventional coil springs has undersized life as compared to the better-quality wave springs and gets nonuse after a heavy shock or jerk due to which they have to be changes at times but the wave springs investigative calculation state that its ability to absorb shocks is much more than the regular coil spring and its life is many times more than that of conventional coil springs.

Fig.1 Coil Spring & Wave Spring

In developing a spring structure by coiling a spring material having at cross section, a clothed curve is selectively used as a shape-determining factor for the spring structure.

Fig.2 Design Pattern of Wave Spring

II. DIFFERENT TYPES OF WAVE SPRING

Multiple types of wave spring are available:

Single-turn wave springs contain gap single-turn and overlap single-turn type. Multi-turn wave spring types, contain shim-end and plain-end types. The nested wave spring incorporates smaller waves within larger ones.

2.1 SINGLE-TURN WAVE SPRING

Single-turns are greatest for applications with short deflection and low to medium forces. The number of waves and material thickness can be changed to accommodate stronger forces. It is used for bearing pre-load.

2.2 MULTI-TURN WAVE SPRING

A multi-turn wave spring can decrease the desired axial space. It is suitable for applications with large deflection and a small spring rate. A extensive range of forces can be accommodated.

2.3 NESTED WAVE SPRING

Excludes the need to stack springs to accommodate higher loads. It produces high force while preserving the precision of a circular-grain wave spring. It substitutes a stack of Belleville washers where a high but accurate force is needed.

III. MATERIAL USED

The coil shape of the said wave spring is selected such that the magnitude of a deflection produced when the wave spring is subjected to an axial compression load P lies in a predetermined region of elastic deformation of the spring material, eg steel.

The material selection is the most important part for developing wave springs because the suitable material selection controls the performance of the product.

- Carbon steel (standard)
- Stainless steel (best suited for high stress, fatigue applications)
- Beryllium copper (corrosion resistance, particularly in marine environments)
- Inconel (best suited for high temperature and corrosive environments)
- Elgiloy (corrosion resistance, particularly in marine environments)

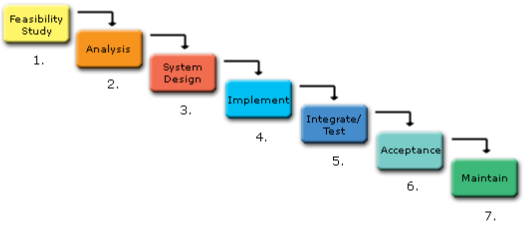
The wave spring shock absorbers using carbon fiber will be costlier but it will be light weight so the cheap vehicles will be provided with the steel wave spring shock absorbers.

IV. WORKING & IMPLITATION

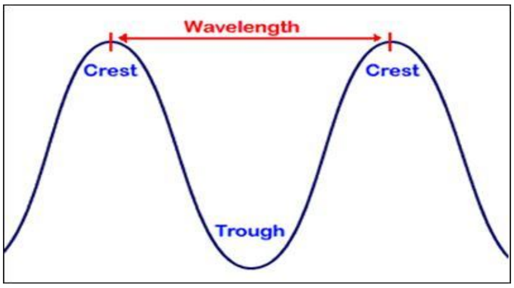
As a means for solving the above problems, the present invention provides a wave spring formed by coiling a spring material of a cross section, said wave spring being characterized in that said spring material which circumferentially extends has a shape represented by a clothoid curve and in that linearity is retained in the relation between a load imposed on said wave spring and a deflection produced thereby, and also provides a wave spring characterized in that the curved portion of said wave spring coiled in clothoid form is formed with a parallel portion in at developed form, said parallel portion being tangentially connected to the terminal end of said clothed curve.

In forming a spring structure by coiling a spring material of a cross section, said circumferentially extending spring material is given a shape represented by a clothed curve.

Since such clothed curve has a characteristic in which the radius of curvature continuously varies in inverse proportion to the length of the curve, linearity can be retained in the relation between load P and deflection S easily as compared with the modified sine curve or modified trapezoidal curve in which no continuity is seen in changes in radius of curvature.



(a)



(b)

Fig.1 (a) & (b) Wavelength & Design Method

4.1 SELECTION OF PARTS FOR SHOCK ABSORBERS

- Crest to crest wave springs
- Dampers

- Stabilizing bar
- Suspension fluids

4.2 INTEGRAL PARTS OF THE SYSTEM

4.2.1 WAVE SPRINGS

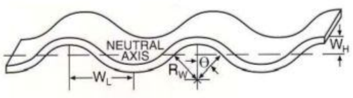
The wave spring is the unique part or the unconventional thing which is added to the newly developed shock absorber suspension system in which the wave springs help to reduce the space and give almost the same outcome.

4.2.2 DAMPERS:

A shock absorber (in reality, a shock "damper") is a mechanical or hydraulic device designed to absorb and damp shock impulses. It does this by converting the kinetic energy of the shock into another form of energy (typically heat) which is then dissipated. Most shock absorbers are a form of dashpot

4.2.3 CALCULATION:

- Thickness of steel band (T) 1.2 mm
- Width of steel band (W) 5.5 mm
- Coil radius of steel band (R) 39.75 mm
- Height of wave (H) 1.5 mm
- Number of ridges per turn of coil 5.5 ridges per turn
- Angle per ridge (6) 32.73 x 2°
- Clothoid curve (CLO) 45.53 m 50.10 mm
- Modifed sine curve (TMS) 44.28 m 48.61 mm
- Size of Circumferential O 4.54 mm
- Parallel length
- portion Angle 0° 655°



$$R_w = \frac{(4W_H^2 + W_L^2)}{8W_H} \qquad \Theta = ArcSin\left(\frac{(W_L)}{2R_W}\right) \qquad W_L = \frac{\pi D_m}{2N} \qquad W_H = \left(\frac{\frac{L}{Z} - t}{2}\right)$$

(a)

Fatigue Stress Ratio	Estimated Cycle Life
.00 < X < .40	Under 30,000 cycles
.40 < X < .49	30,000 - 50,000 cycles
.50 < X < .55	50,000 - 75,000 cycles
.56 < X < .60	75,000 - 100,000 cycles
.61 < X < .67	100,000 - 200,000 cycles
.68 < X <.70	200,000 - 1,000,000 cycles
.70 < X	over 1,000,000 cycles

(b)

calculate cycle life:

$$\text{Fatigue Stress Ratio} = X = \frac{(\sigma - S_1)}{(\sigma - S_2)}$$

Where:

σ = Material tensile strength

S1 = Calculated operating stress at lower work height

S2 = Calculated operating stress at upper work height

(c)

Fig.1 (a), (b), & (c) Calculation Diagram & Life cycle of Wave Spring

V. DISCUSSION

5.1 ADVANTAGES

A wave spring has advantages over a conventional coiled spring or a washer:

Axial space can be reduced by up to 50%. As a result, the overall size of the assembly becomes smaller, reducing weight and production cost.

The load in an axial direction is 100% transferable. One multi-turn wave spring replaces multiple stacked wave washers. This eases installation and reduces maintenance times.

A wave spring can accommodate higher thrust load within the axial space as only the wire size, number of waves, wave height and number of turns need to be adjusted to accommodate higher thrust loads.

5.2 APPLICATIONS

- Wave springs can be used in shock absorbers.
- They can be also used in clutches.
- The carbon wave springs can also be used in sports car to reduce weight.
- It can be used in heavy industries

5.3 FUTURE SCOPE

The wave springs biggest advantage is that it fits in half space that of the conventional springs and in future the vehicles will be compact so there is a large scope for wave springs in the field of the automobile.

5.4 RESULT AND CONCLUSION

As a result, buckling ascribable to the nonlinearity of changes in radius of curvature is substantially avoided. The space and the efficiency of the wave springs brings a new technology that can be implemented wherever and has a huge scope in future because of its compact size.

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