

Experimental analysis of helical compression spring used in two wheeler suspension system

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Abstract

The helical compression spring used in two wheelers is belonging to the medium segment of the Indian automotive market. The detailed assessment of the problem of two wheeler suspension spring is studied. Most of time springs were failed due to raw material defects, surface imperfection, improper heat treatment, corrosion and decarburization and high weight of suspension. These problems can be solved by applied thick layer of paint as adhesive, proper heat treatment, change in shape and material of helical compression spring. In this work, the spring rate can be increased by change in structure i.e. change in number of active coils of spring. Theoretical and experimental work is done. Results obtained are compared.

Keywords: helical compression spring, two wheeler, raw material, paint, spring rate.

1. Introduction

A. Suspension system

Suspension system consists of a spring and a damper. The energy of road shock cause the spring to oscillate. These oscillations are restricted to a reasonable level by the damper which is more commonly called a shock absorber. The vehicle suspension system is responsible for the vehicle control, Driving comfort and safety as the suspension carries the vehicle body and transmit all the forces between the rod and the body.

B. Spring

A spring is defined as an elastic machine element that deflects under the action of the load and returns to its original shape when the load is removed. It can take any shape and form depending upon the application.

C. Helical spring

The helical springs are made up of a wire coiled in the form of helix and are primarily intended for compressive or tensile loads. The cross-section of wire from which the spring is made may be circular, square or rectangular. The two forms of helical springs are compression helical spring and tension helical spring. The most popular type of spring is helical compression spring. There are two basic types of helical compression spring Compression spring and Extension spring. In helical compression spring, the external force tends to shorten the spring. The external force acts along the axis of the spring and induces torsion shear stress in the spring wire. It should be noted that although the spring is under compression, the wire of helical compression spring is not subjected to compression stress. Also the wire is not subjected to tensile stress although the spring is under tension. In both cases, torsion shear stresses are induced in the spring wire. The helical spring sometimes classified as closely coiled helical spring and open coiled helical spring

2. LITERATURE REVIEW

A. Review of papers

B.Ravi Kumar et al. (2002) studied a failed helical spring used in coke oven batteries for the cause of failure. The spring had four active coils used for expansion or contraction in the coke oven battery. Visual examination of general features indicated the fracture took place in fourth active coil from bottom. The surface of the spring was covered with a thick layer of weakly adhering corrosion product. Chemical analysis of spring material was done. X-Ray diffraction (XRD) phase analysis of the corrosion product indicated Fe_3S_4 , Fe_9S_{10} , $FeOCl.NH_3$ and iron oxide.

The fracture surface was cut and cleaned. Macrofractography of the fracture surface was conducted using a stereomicroscope. A bench mark was found on the failed surface.

L.DelLiano-Vizcaya(2007) studied the manufacturing process of mechanical spring and observed that tensile residual stresses induces on the inner coil surface while compressive residual stresses were generated on outer coil surface which reduces considerably the spring strength and service life. These unfavorable stresses partially eliminated by heat treatment.

Youli Zhu, Yanli Wang et al. (2014) analyzed why a compressive coil spring fractured at the transition position from the bearing coil to the first active coil in service. While the nominal stress should always much less than at the insides coil position of a fully active coil. Visual observation indicated that a wear scar was formed on the first active coil. Scanning electron microscopy examination showed crescent shaped region and bench marks. Zncaph phosphate layer and painting around the contact zone were worn out due to contact and friction and Resulted into corrosion.

R. Puff et al. (2014) investigated the effect of the presence of non-metallic inclusions in the early failure of a helical spring subjected to regular design loads during its operation. To understanding the reduction in fatigue strength, an analytical model was used.

3. Existing spring specifications

- a) Outside diameter = 49mm
- b) Inside diameter = 35mm
- c) Mean diameter = 42mm
- d) Wire diameter = 7mm
- e) Free length = 230mm
- f) no. of total coils = 19
- g) no. of active coils = 17
- f) Chemical composition

C = 0.74, Mn = 0.74, Si = 0.21, s = 0.016, P = 0.016, Cr = 0.18

Existing spring material – En 42 spring steel.

4. Theoretical calculations

4.1 Mean Coil Diameter

$$D = \frac{D_o + D_i}{2}$$

$$D = \frac{49+35}{2} = 42 \text{ mm}$$

4.2 Spring Index

$$C = \frac{D}{d}$$

$$C = \frac{42}{7}$$

$$C = 6$$

C is in between 5to 9 so it is suitable for cyclic loading. Also it is suitable for manufacturing.

4.3 Wahl Factor (K)

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

$$K = \frac{4(6) - 1}{4(6) - 4} + \frac{0.615}{6}$$

$$K = 1.2525$$

4.4 Exiting Design

Total number of coils = 19

Number of active coils = 17

4.4.1 Stiffness

$$K_1 = \frac{Gd^4}{8D^3N} = \frac{79000 \times 2401}{8 \times 74088 \times 17}$$

$$K_1 = 18.82 \text{ N/mm}$$

$$K_1 = 1.9184 \text{ Kg/mm}$$

4.4.2 Now calculating load for deflection is 10mm

$$\text{Deflection } (\delta) = \frac{P_1}{K_1}$$

$$10 = \frac{P_1}{1.9184}$$

$$P_1 = 19.84 \text{ Kg}$$

4.5 New spring design I

Total number of coils = 17

Number of active coils = 15

4.5.1 Stiffness

$$K_2 = \frac{Gd^4}{8D^3N} = \frac{79000 \times 2401}{8 \times 74088 \times 15}$$

$$K_2 = 21.33 \text{ N/mm}$$

$$K_2 = 2.1743 \text{ Kg/mm}$$

4.5.2 Now calculating load for deflection is 10mm

$$\text{Deflection } (\delta) = \frac{P_2}{K_2}$$

$$10 = \frac{P_2}{2.1743}$$

$$P_2 = 21.743 \text{ Kg}$$

4.6 New Spring design II

Total number of coils = 15

Number of active coils = 13

4.6.1 Stiffness

$$K_3 = \frac{Gd^4}{8D^3N} = \frac{79000 \times 2401}{8 \times 74088 \times 13}$$

$$K_3 = 24.6171 \text{ N/mm}$$

$$K_3 = 2.509 \text{ Kg/mm}$$

4.6.2 Now calculating load for deflection is 10mm

$$\text{Deflection } (\delta) = \frac{P_3}{K_3}$$

$$10 = \frac{P_3}{2.509}$$

$$P_3 = 25.09 \text{ Kg}$$

The load for different deflection was calculated and tabulated below with reference to above calculated stiffness for various springs.

Table no.1 Load vs. Deflection for various springs (theoretical)

deflection (mm)	loads at various deflections in N				
	10	20	30	40	50
existing spring	188.2	376.4	564.6	752.8	941
new spring I	213.3	426.6	639.9	853.2	1066.5
new spring II	246.1	492.3	738.5	984.6	1230.8

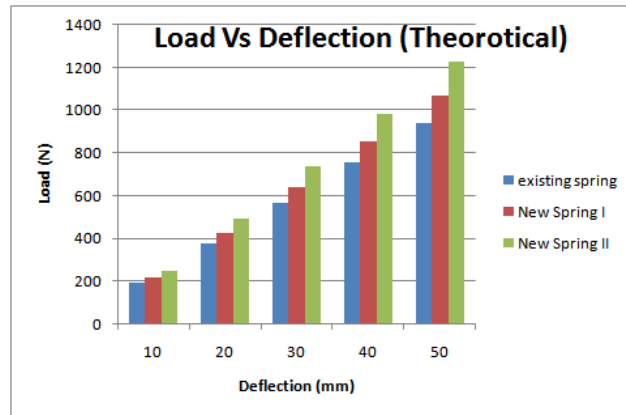


Fig. 1 Graph of load vs deflection (theoretical)

5. Experimental investigation of suspension spring

Test Procedure

1. The experimental study was carried out for design validation. Physical testing on the spring in compression is done as accordance to Compression Testing.
2. The testing was done by 10 ton universal testing machine, UTM along with load cell having load carrying capacity 1000 kg. It was made by Star Testing Systems, India and is computerized and software based.
3. Number of coil springs that are used for testing is three pieces. The one spring was tested at a time.
4. The tested springs were mounted both on top and bottom, at specially made seats. After this the spring is compressed for different deflections and applied load is recorded by the use of load cell.
5. Results produced from the testing i.e. spring constant, maximum force and compression are to be verified for their particular specification conformity.

Table no.2 Load vs deflection for various springs (experimental)

deflection (mm)	loads at various deflections in N				
	10	20	30	40	50
existing spring	185.4	375.7	566.3	756.3	944.7
new spring I	210.9	419.8	630.7	837.7	1047.7
new spring II	211.8	450.2	684.7	920.1	1154.6

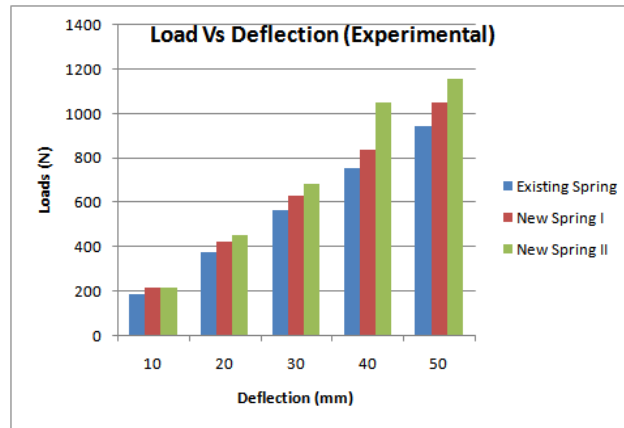


Fig. 2 Graph of load vs deflection (Experimental)

6. Conclusion

Analysis of helical compression spring used in two wheeler suspension system is done with the help of theoretical and experimental work. For this purpose three springs are used namely existing spring, new spring I and new spring II. For experimental work universal testing machine (UTM) is used. For given deflection, loads are find out. It is concluded that load carrying capacity of new spring II is increased than existing & new spring I.

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