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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. The static stress analysis using finite element method will be validating by experimental validation.

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

I. INTRODUCTION

1. 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.

2. 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.

3. 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

II. EXISTING PROBLEM

A problem in helical compression spring start before the manufacturing of the spring i.e. entries of foreign particle into raw material of helical compression spring called as imperfections. Surface imperfections can also occur as small hardening cracks and tool marks, poor shot penned surfaces.

Improper heat treatment can also overlook. During manufacturing of spring, residual stresses are generated on inner and outer surface of the spring. Decarburization can take place when the material is heated to the temperature of 700^0C or above. The most common problem in the springs is wear scar that will result into corrosion although thick layer of a paint or polymer basis is applied over the spring.

III. PROBLEM STATEMENT

The detailed assessment of the problem of helical compression spring used in two wheeler suspension system is studied. Problems in helical compression spring are

- Major causes of failure of helical compression spring are due to wear scar which results into corrosion.
- Raw material defect may exhibit internal cracking.
- Surface imperfection can affect the strength of the spring.
- Improper heat treatment during manufacturing can affect the fatigue life of spring.

IV. OBJECTIVES

Study the different parameters of existing spring.

- Design and development of required spring.
- Modeling and analysis of exiting spring.
- Modeling and analysis of new spring.
- Experimental validation.

V. LITERATURE REVIEW

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 Fe3S4, Fe9S10, Feocl.NH3 and iron oxide. The fracture surface was cut and cleaned. Macrofactography of the fracture surface was conducted using a stereomicroscope. A bench mark was found on the failed surface.

L. Del Liano-Vizcaya et al. (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.

VI. EXISTING SPRING SPECIFICATIONS

- Outside diameter = 49mm
- Inside diameter = 35mm
- Mean diameter = 42mm
- Wire diameter = 7mm
- Free length = 230mm
- no. of total coils = 19
- no. of active coils = 17
- 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.

VII. THEORETICAL CALCULATIONS

1. Mean Coil Diameter:

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

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

2. Spring Index:

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

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

$$\mathbf{C = 6}$$

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

3. Wahl Factor (K):

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

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

$$\mathbf{K = 1.2525}$$

4. Exiting Design:
Total number of coils = 19
Number of active coils = 17

Stiffness

$$\mathbf{K_1 = \frac{Gd^4}{8D^3N} = \frac{79000\,x\,2401}{8x74088\,x17}}$$

K_1 = 18.82 N/mm
K_1 = 1.9184 Kg/mm

Now calculating load for deflection is 10mm

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

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

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

5. New spring design I:
Total number of coils = 17
Number of active coils = 15

Stiffness

$$K_2 = \frac{Gd^4}{8D^3N} = \frac{79000 \times 2401}{8x74088 x15}$$

K_2 = 21.33 N/mm
K_2 = 2.1743 Kg/mm

Now calculating load for deflection is 10mm

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

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

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

6. New Spring design II:
Total number of coils = 15
Number of active coils = 13

Stiffness

$$K_3 = \frac{Gd^4}{8D^3N} = \frac{79000 \times 2401}{8x74088 x13}$$

K_3 = 24.6171 N/mm
K_3 = 2.509 Kg/mm

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.

Table1. Load vs. deflection for various springs (theoretical).

	loads at various deflections in N				
deflection (mm)	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

VIII. STATIC ANALYSIS

For the above specification of the helical compression spring, the static analysis is performed using ANSYS 16.2 to find out the maximum deflection for the corresponding theoretical load. The analysis results are as follows

1. Existing Spring:
Theoretical loads 376.4N, 752.8N are applied on the spring.

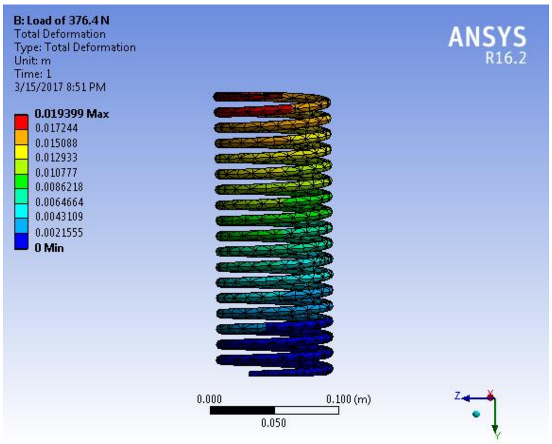

Fig 1. Maximum deflection at load 376.4 N.

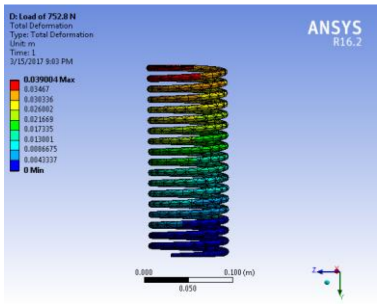

Fig 2. Maximum deflection at load 752.8 N.

2. New spring I:

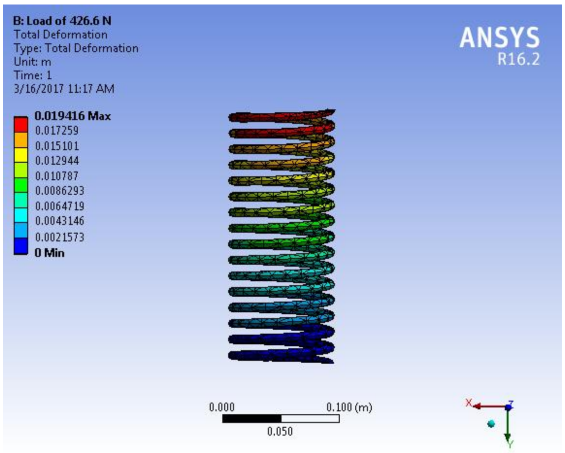

Fig 3. Maximum deflection at load 426.6 N.

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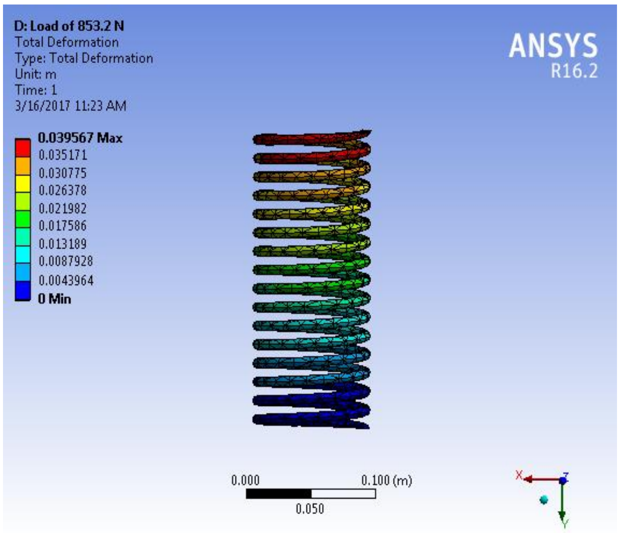

Fig 4. Maximum deflection at load 853.2 N

3. New Spring II:

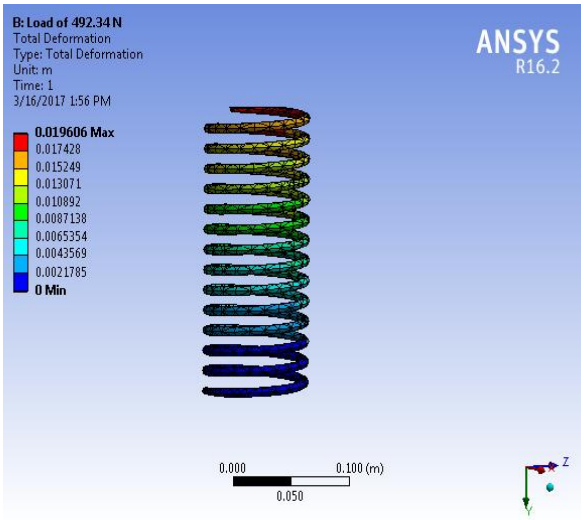

Fig 5. Maximum deflection at load 492.3 N.

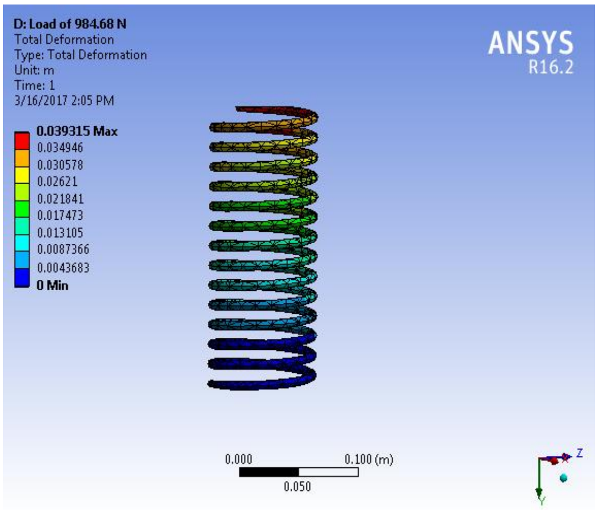

Fig 6. Maximum deflection at load 984.6 N.

IX. EXPERIMENTAL INVESTIGATION OF SUSPENSION SPRING

1. Load Verses Deflection Test:

- The experimental study was carried out for design validation. Physical testing on the spring in compression is done as accordance to Compression Testing.
- 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.
- Number of coil springs that are used for testing is four pieces. The one spring was tested at a time.
- 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.
- Results produced from the testing i.e. spring constant, maximum force and compression are to be verified for their particular specification conformity.

Table 2. Load vs deflection for various springs (experimental)

	loads at various deflections in N				
deflection (mm)	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

X. DISCUSSIONS

From the above study it is observed that the modification in the spring is resulted in weight reduction. Material required for modified spring is reduced. Load carrying capacity of the modified spring is increased.

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