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Optimization of Three Wheeler Front Suspension Coil Spring

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Abstract

The helical compression spring used in suspension system or shock absorber is a mechanical device designed to smooth out or damp shock impulse and dissipate kinetic energy. A helical compression coil spring which used in transport three wheeler is belonging to the medium segment of the Indian automotive market. It is 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 IS 4454 material was taken for consideration. Optimization of the spring was done by reducing total number of turns and prototypes of the spring were made. As per design the springs were made of material IS 4454 and experimental test was conducted. The static analysis using finite element method has been done in order to find out the detailed load vs defection of the spring. The experimental investigation was performed to calculate the stiffness and vertical acceleration of helical compression spring. The theoretical calculations were also done. For experimental test the universal testing machine was used to find load vs defection of spring and quarter car test rig used to find the vertical acceleration of helical compression spring.

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Keywords: Coil spring; three wheeler; optimization; analysis

1. Introduction

When people think about automobile performance, they normally think of hp, torque, acceleration and most

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important comfort. So, the suspension is an important system in an automobile and much attention is given to it. The vehicle suspension system is responsible for the vehicle control, driving comfort and safety as the suspension carries the vehicle body and transmits all the forces between the road and the body.

Suspension system consist of different parts such as spring, shock absorber etc. In most of the suspension system the spring plays an important role. The springs having different types like push type, pull type etc.

In some three wheelers the front suspension is at one side of tire. Normally, it is observed that the vehicle drifts towards one side due to high weight of front suspension system. The study is performed to reduce the weight of helical compression spring used in three wheeler front suspension system. The objective of the present work is to optimize the front suspension system's component i. e. helical compression spring by achieving minimum of 8% to 10% reduction in weight and so in cost.

Researchers were used various methods for analysis and optimization of coil spring. M. P. Nagarkar, Dr. G. J. Vikhe Patil, R. N. Zaware Patil [1] investigated a nonlinear quarter car suspension–seat–driver model for optimum design. A nonlinear quarter car model comprising of quadratic tyre stiffness and cubic stiffness in suspension spring, frame, and seat cushion with 4 degrees of freedom (DoF) driver model was presented for optimization and analysis. Non-dominated Sort Genetic Algorithm (NSGA-II) and Multi-Objective Particle Swarm Optimization – Crowding Distance (MOPSO-CD) algorithm are implemented for optimization. Tausif M. Mulla, Sunil J. Kadam, Vaibhav S. Kengar [2] studied the stress analysis of a helical coil compression spring which was employed in three wheeler's auto-rickshaw belonging to the medium segment of the Indian automotive market. The material used for study was ASTM A227. To ensured structural reliability of spring the static stress analysis using finite element method has been done in order to find out the detailed stress distribution of the spring. The stress distribution clearly shows that the shear stress having maximum value at the inner side of the every coil.

2. Design of suspension spring

2.1 Equations used for spring design

To design the spring and determine the stress developed in the spring consider a helical spring subjected to an axial load P. [5]

Let, D = Mean diameter of the spring coil (mm), D_o = Outside diameter of the spring coil (mm), D_i = Inside diameter of the spring coil (mm), d = Diameter of the spring wire (mm), N = Number of active coils, N_t = Total number of coils, G = Modulus of rigidity for the spring material, P = Axial load on the spring (N or Kg), τ = Max. Shear stress induced in the wire (N/mm^2), C = Spring index = D/d, p = Pitch (mm), δ = Deflection of the spring, as a result of an axial load P, L = Free Length (mm), K = Wahl factor, k = Stiffness of the spring (N/mm).

The equations required for the design of the spring are as follows;

a) Spring Index (C) = D/d (1)

b) Wahl's Stress factor (K) = $\frac{4C-1}{4C-4}+\frac{0.615}{C}$ (2)

c) Stiffness = $(G\times d^4)/(8\times D^3\times N)$ N/mm and divide by 10 for kg/mm (3)

d) Shear Stress (τ) = $\frac{K\times 8\times P\times D}{\pi\times d^3}=\frac{K\times 8\times P\times C}{\pi\times d^2}$ N/mm^2 (4)

e) Solid Length = $N_t \times d$ (5)

f) Deflection (δ) = P/k mm (6)

2.2 Spring Data

The existing suspension spring weighing 2.90 Kg is heavy hence needed to be optimized and a lighter design of the spring is needed. The existing suspension spring having wire diameter 12 mm, with outside and inside diameter 88 mm and 64 mm respectively, total number of coils 14, number of active coils 12 and free length 315 mm. New designs have same data as of existing spring only total numbers of coils changed so active coils are also changed. The three designs having 13, 12.5 and 12 total coils having 2 coils inactive in each case respectively. By using above equations different values can be found for new developed springs.