Design and Analysis of Helical Coil Spring in Suspension System

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Abstract—In a vehicle, problems happen while driving on bumping road condition. The aim of our project is to design and analyze the performance of Shock absorber by changing the wire diameter of the coil spring. The Shock absorber is one of the Suspension systems is designed to handle shock impulse and dissipate kinetic energy. It decreases amplitude of disturbances leading to increase in comfort and improved ride. The spring is compressed when the wheel strikes a bump. The compressed spring rebound to its normal dimension which causes the body to lift up. The spring goes down below its normal length when the weight of the vehicle pushes the spring down. The spring bouncing process occurs again and again, until the up-and-down movement finally stops. Hence, spring design in a suspension system is utmost crucial. The analysis is performed by considering the bike mass and with persons seated on the bike. Comparison is done by changing the wire diameter of the coil spring to check the best dimension for the spring in shock absorber. Modeling and Analysis is done by using Pro/ENGINEER and ANSYS respectively

Keywords— ANSYS, Coil Spring, Modified design, Stress and deformation analysis, Suspension.

1. INTRODUCTION
Shock absorber is designed to handle shock impulse and dissipate kinetic energy. The Design is an important activity which influences the quality. The Shock absorber coil spring is designed by using the solid modeling software Pro/ENGINEER. In modeling, the time is spent on drawing the coil spring model and the risk involved in design and manufacturing process can be easily reduced. Later this Pro/ENGINEER model is imported to ANSYS for analysis. The ANSYS software is used for analyzing the component by varying the load applied on it and the results are tabulated.

1.1. Applications
Shock absorbers are an important part of automotive suspensions and aircraft landing gear.

1.2. Working of Shock absorbers Spring
Shock absorbers work in two cycles—compression cycle and the extension cycle. The compression cycle occurs as the piston moves downward, compressing the hydraulic fluids in the chamber below the piston. Extension cycle occurs as the piston moves toward the top of the pressure tube, compressing the fluid in the chamber above the piston.

2. PROBLEM DEFINITON
The important problem that is faced by the automotive industry is that the vehicle handling becomes difficult and leads to uncomfortable ride when spring bouncing is uncontrolled. This is based on a number of parameters such as load applied and the duration of it. Therefore the existing design is modified in order to minimize the stress and discomfort experienced by the passengers. In this study, calculations are done analytically and trials are conducted by simulation, in order to find out the results.

3. OBJECTIVE
• To study the various parameters influencing the stress and deformation induced.
• To conduct experiments on Helical coil compression springs to obtain desired results.
• To compare the results of existing and modified design through ANSYS and analytical methods for different load conditions.
4. DESIGN CALCULATION FOR PRESENT DESIGN HELICAL COIL SPRING (WIRE DIA 7.0MM)

Material: Spring Steel (Modulus of Rigidity) G = 78600 pa
Young’s Modulus (EX): 1.965×10^5 pa
Poisson’s Ratio (PRXY): 0.25
Density: 7.86×10^6 kg/mm^3

Total no of coils, n_t = 17
No of active turns, n_a = 15
Spring index (C) = 6 where C = D/d
Wire diameter d = 7.0 mm
Mean diameter of a coil, D = 7.0x6 = 42 mm
Outer diameter of spring coil, D_o = D + d = 49 mm
Inner diameter of spring coil, D_i = D – d = 35 mm

Structural Analysis for the bike weight (120 kg) with 2 Person

\[ \tau = k \left( \frac{8WC}{\pi d^2} \right) \]
\[ \tau = 1.25 \left( \frac{8 \times 1784 \times 6}{\pi \times (7)^2} \right) \]
Shear stress (\( \tau \)) = 695 N/mm^2
Weight of the bike = 120 kg
Let weight of 1 person = 70 kg
Weight of 2 persons = 2x70 = 140 kg
Weight of bike + persons = 260 kg
Rear Suspension = 70%
70% of 260 = 182 Kg
Considering dynamic loads it will be double
W = 364 Kg = 3568 N
For single shock absorber weight = w/2 = 1784 N = W
Solid length, L_s = n_t x d = 17x7.0 = 119 mm
compression of spring (\( \delta \)) = \( \frac{8WDn_a}{Gd^4} \)
\[ \delta = \frac{8 \times 1784 \times 6^2 \times 15}{(78600 \times 7.0^4)} = 84.04 \text{ mm} \]
compressed length (L_c) = solid length (L_s) + 15% of \( \delta \)
L_c = 131.6 mm
Free length (L_f) = L_c + \( \delta \) = 215.6 mm
Pitch (p) = L_c / n_a = 13.47 mm
Spring rate, K = W / \( \delta \) = 1784/84.04 = 21.22 N/mm.

5. INTRODUCTION TO PRO/ENGINEER

Pro-ENGINEER is a feature-based, solid modeling program. Its application is significantly different from conventional drafting programs. In conventional drafting (either manual or computer assisted), various views of a part are created to describe the geometry. The design procedure is to create a model, view it, and generate any drawings which are required.

5.1. Capabilities of the software
It is continually being developed to include new functions. The details below aim to outline the scope of capabilities to show an overview rather than giving specific details on the individual functions of a product. The Pro/Engineer is a software application within the CAD/CAM/CAE category. It is a feature-based modeling architecture incorporated into a single database philosophy with advanced rule-based design capabilities. The capabilities of the product can be divided into the three main heading as Engineering Design, Analysis and Manufacturing.

5.2. Design Tools
The Pro/Engineer offers a wide range of tools for a complete digital representation of the product being designed. A number of concept design tools that provide up-front Industrial Design concepts can be used in the downstream process of engineering the product.

A. Model of the Coil Spring

1) Present Design of the Coil Spring

![Fig 5.1 Isometric view of spring 7mm](image1)

![Fig 5.2 Part Drawing of spring 7 mm](image2)
2) Modified Design of the Coil Spring

6. ANALYSIS OF THE COIL SPRING

Static analysis calculates the effects of steady loading conditions on a structure such as those caused by time-varying loads. A static analysis, however, includes steady inertia loads and time-varying loads.

6.1 Analysis The type of structural analysis performed depends on the product being tested, the nature of the loads, and the expected failure. A short structure will most likely fail due to material failure. For the given below specification of the springs, the static analysis is performed using ANSYS to find the maximum safe stress and the corresponding pay load. After geometric modeling of the spring with given specifications it is subjected to analysis. The Analysis involves the following sequence called meshing, boundary conditions and loading.

6.2 About Analysis with ANSYS We consider ANSYS software for our analysis to obtain accurate results. The ANSYS computer program is a large-scale finite element program. ANSYS is used for solving several engineering applications. The analysis capabilities of ANSYS include the ability to solve static and dynamic structural analyses.

A. Present Design of the spring
Structural Analysis for the bike weight (Load: 120 kg)

ON APPLYING LOAD:

RESULT AFTER APPLYING LOAD:
B. New Modified Design Of The Spring

Structural Analysis for the bike weight (Load: 120 kg)

ON APPLYING LOAD:

RESULT AFTER APPLYING LOAD:

7. RESULTS AND DISCUSSION

Stress and Deformation values for present and modified design of the helical compression spring are found out through ANSYS and theoretical calculations for different bike loads and compared.

<table>
<thead>
<tr>
<th>S. NO</th>
<th>LOADING DESCRIPTION</th>
<th>LOADING</th>
<th>STRESSES ON COIL SPRING (Mpa)</th>
<th>DEFORMATION ON COIL SPRING (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>BIKE LOAD</td>
<td>120 Kg</td>
<td>321</td>
<td>38.8</td>
</tr>
<tr>
<td>2.</td>
<td>BIKE LOAD +1 PERSON</td>
<td>190 Kg</td>
<td>508</td>
<td>61.4</td>
</tr>
<tr>
<td>3.</td>
<td>BIKE LOAD +2 PERSON</td>
<td>260 Kg</td>
<td>695</td>
<td>84.0</td>
</tr>
</tbody>
</table>
8. CONCLUSION

In this study, the shock absorber has been redesigned so that the stress acting on the shock absorber is reduced. The proposed redesign will reduce the deformation and induced stress magnitude for the same applied loading conditions when compared with the existing design. This in turn increases the life of the shock absorber by reducing its failures. The analytical results conform to the simulation results from the ANSYS.

9. REFERENCES


