DESIGN AND ANALYSIS OF HELICAL SPRINGS IN TWO WHEELER SUSPENSION SYSTEM

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Abstract: The main part for a vehicle suspension is the shock absorber, which is manufactured for reducing shock impulse. Shock absorber work on the principle of fluid displacement on compression and expansion cycle. They are used in motorcycles for providing better handling, prompt braking, safety and comfort by keeping the passengers isolated from road noise, bumps and vibration. The common type of the front suspension in motorcycle is Telescopic forks which are replaced by the Mono Shocks that gives a superior vehicle handling and provides safety while braking. Mono shock also allows the rider to fine tune the machine to give better control over the machine when riding. The springs in Mono Shock have been designed by taking considerations of many practical conditions like dynamic resistances, road tracks and aerodynamic properties. In this design the uneven vibrations in the telescopic forks have been balanced by using the Mass Centralization concept in the pivoted centre point of the front suspension in the motorcycle using Mono Shocks. The Mono Shock geometry gives a rising rate of damping characteristics to the front suspensions and the designed springs used to restrict a downgraded dynamics when it returns to the immobility state posterior to humps and bumps. This design of front suspension using mass centralization concept may antiquate the present telescopic forks

1. INTRODUCTION

The suspension system is the main part of the vehicle, where the shock absorber is designed mechanically to handle shock impulse and dissipate kinetic energy. In a vehicle, shock absorbers reduce the effect of traveling over rough ground, leading to improved ride quality and vehicle handling. While shock absorbers serve the purpose of limiting excessive suspension movement, their intended sole purpose is to damp spring oscillations. Hysteresis is the tendency for otherwise elastic materials to rebound with less force than was required to deform them. Hence, the designing of suspension system is very crucial. In modeling the time is spent in drawing the coil spring model and the front suspension system, where risk involved in design and manufacturing process can be easily minimized. So the modeling of the coil spring is made by using SOLID WORKS. Later the model is imported to ANSYS for the analysis work.

Fig1: Spring Suspension System
1.1 SPRING SUSPENSION SYSTEM

1.1.1 Explanation

The shock absorbers duty is to absorb or dissipate energy. One design consideration, when designing or choosing a shock absorber, is where that energy will go. In most dashpots, energy is converted to heat inside the viscous fluid. In hydraulic cylinders, the hydraulic fluid will heat up, while in air cylinders, the hot air is usually exhausted to the atmosphere. In other types of dashpots, such as electromagnetic ones, the dissipated energy can be stored and used later. In general terms, shock absorbers help cushion cars on uneven roads.

1.1.2 Front suspension

Motorcycle's suspension serves a dual purpose: contributing to the vehicle's handling and braking, and providing safety and comfort by keeping the vehicle's passengers comfortably isolated from road noise, bumps and vibrations. The typical motorcycle has a pair of fork tubes for the front suspension. The most common form of front suspension for a modern motorcycle is the telescopic fork. Other fork designs are girder forks, suspended on sprung parallel links and bottom leading link designs. Some manufacturers used a version of the swinging arm for front suspension on their motocross designs. The top of the forks are connected to the motorcycle's frame in a triple tree clamp which allows the forks to be turned in order to steer the motorcycle.

1.1.3 Vehicle suspension

![Vehicle Suspension System](image)

**Fig2: Vehicle Suspension System**

In a vehicle, it reduces the effect of traveling over rough ground, leading to improved ride quality, and increase in comfort due to substantially reduced amplitude of disturbances. Without shock absorbers, the vehicle would have a bouncing ride, as energy is stored in the spring and then released to the vehicle, possibly exceeding the allowed range of suspension movement. Control of excessive suspension movement without shock absorption requires stiffer (higher rate) springs, which would in turn give a harsh ride. Shock absorbers allow the use of soft (lower rate) springs while controlling the rate of suspension movement in response to bumps. They also, along with hysteresis in the tire itself, damp the motion of the unsprung weight up and down on the springiness of the tire. Since the tire is not as soft as the springs, effective wheel bounce damping may require stiffer shocks than would be ideal for the vehicle motion alone. Spring-based shock absorbers commonly use coil springs or leaf springs, though torsion bars can be used in tensional shocks as well. Ideal springs alone, however, are not shock absorbers as springs only store and do not dissipate or absorb energy. Vehicles typically employ springs and torsion bars as well as hydraulic shock absorbers. In this combination, "shock absorber" is
reserved specifically for the hydraulic piston that absorbs and dissipates vibration.

1.2 Introduction to Solid Works:
Solid works mechanical design automation software is a feature-based, parametric solid modeling design tool which advantage of the easy to learn windows graphical user interface. We can create fully associate 3-D solid models with or without while utilizing automatic or user defined relations to capture design intent.

Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allow them to capture design intent.

1.3 Different Modules in Solid Works
- PART DESIGN
- ASSEMBLY
- DRAWING
- SHEETMETAL
- ANALYSIS

By using the solid works software was designed the 3D model of solid and spring because compared to the other 3D software’s solid works is easy to design.

Fig3: Spring model

1.4 Introduction to Ansys
Many problems in engineering and applied science are governed by differential or integral equations. The solutions to these equations would provide an exact, closed form solution to the particular problem being studied. However, complexities in the geometry, properties and in the boundary conditions that are seen in most real world problems usually means that an exact solution cannot be obtained in a reasonable amount of time. They are content to obtain approximate solutions that can be readily obtained in a reasonable time frame and with reasonable effort. The FEM is one such approximate solution technique.

The FEM is a numerical procedure for obtaining approximate solutions to many of the problems encountered in engineering analysis. In the FEM, a complex region defining a continuum is discretised into simple geometric shapes called elements. The properties and the governing relationships are assumed over these elements and expressed mathematically in terms of unknown values at specific points in the elements called nodes. An assembly process is used to link the individual elements to the linked system. When the effects of loads and boundary conditions are considered, a set of linear or nonlinear algebraic equations is usually obtained. Solution of these equations gives the approximate behavior of the continuum or system. The continuum has an infinite number of degrees of freedom (DOF), while the discreted model has a finite number of DOF. This is the origin of the name, finite element method.
2. LITRETATURE REVIEW

For providing the best design of spring coil to the suspension system of two wheeler vehicles. A lot of technical papers and reduction processes were studied before deciding upon the most feasible process for project. The following list presents a gist of the main papers referred to, throughout the duration of the project.

N.Lavanya[1] The present work is optimum design and analysis of a suspension spring for motor vehicle subjected to static analysis of helical spring the work shows the strain and strain response of spring behaviour will be observed under prescribed or expected loads and the induced stress and strains values for low carbon structural steel is less compared to chrome vanadium material also it enhances the cyclic fatigue of helical spring.

Kommalapati.Rameshbabu [2] In this project they have designed a shock absorber used in a 150cc bike and modeled the shock absorber by using 3D parametric software Pro/Engineer. To validate the strength of design, structural analysis and modal analysis on the shock absorber was done. The analysis was done by varying spring material Spring Steel and Beryllium Copper. By observing the analysis results, the analyzed stress values are less than their respective yield stress values. The design is safe. By comparing the results for both materials, the stress value is less for Spring Steel than Beryllium Copper. By comparing the results for present design and modified design, the stress and displacement values are less for modified design. So they c concluded that as per our analysis using material spring steel for spring is best and also their modified design is safe.

C.Madan Mohan Reddy [3] The comparative study has been carried out in between the theoretical values to the experimental values and the analytical values. The maximum shear stress of chrome vanadium steel spring has 13-17% less with compare to hard drawn steel spring. The deflection pattern of the chrome vanadium steel spring 10%less at specified weight with compare to the hard drawn steel spring. It is observed that 95% of the similarity in deflection pattern and 97% similarity in shear stress pattern between experimental values to the analytical values. It is observed that 60%similarity in between theoretical values of deflection to the experimental values and 85% similarity in maximum shear stress of spring.

S. S. Gaikwed, [4] To prevent the accident and to safeguard the occupants from accident, horn system is necessary to be analyzed in context of the maximum safe load of a helical compression spring. In the present work, helical compression spring is modeled and static analysis is carried out by using NASTRAN software. It is observed that the maximum stress is developed at the inner side of the spring coil. From the theoretical and the NASTRAN, the allowable
design stress is found between the corresponding loads 3 to 6 N. It is seen that at 7N load, it crosses the yield stress (yield stress is 903 N/mm²). By considering the factor of safety 1.5 to 2. It is obvious that the allowable design stress is 419 to 838 N/mm². So the corresponding loads are 3 to 6 N. Therefore it is concluded that the maximum safe pay load for the given specification of the helical compression spring is 4 N. At lower loads both theoretical and NASTRAN results are very close, but when load increases the NASTRAN results are uniformly reduced compared to theoretical results.

3. METHODOLOGIES
3.1 Design Procedure
3.1.1 Spring Specifications
spring wire diameter (d) =8 mm,
Coil mean diameter (D) =40 mm,
Coil free height (h) =180 mm,
No. of active coils (n) =12,
Pitch (P) =15 mm.

3.2 Analysis Steps:
The steps needed to perform an analysis depend on the study type. You complete a study by performing the following steps:
• Create a study defining its analysis type and options.
• If needed, define parameters of your study. A parameter can be a model dimension, material property, force value, or any other input.
• Define material properties.
• Specify restraints and loads.
• The program automatically creates a mixed mesh when different geometries (solid, shell, structural members etc.) exist in the model.
• Define component contact and contact sets.
• Mesh the model to divide the model into many small pieces called elements. Fatigue and optimization studies use the meshes in referenced studies.
• Run the study.
• View results.

3.3 Theoretical Calculations
W= load applied
D= mean diameter
d = spring wire diameter
G= modulus of rigidity
At LOAD =850 N
Spring Index, \( C = \frac{D}{d} = \frac{40}{8} = 5 \)
Shear Stress Factor \( (K) = 1 + \frac{1}{2e} \)
\( = 1 + \frac{1}{2 \times 5} \)
\( (K) = 1.1 \)
Maximum Shear Stress \( (\tau) = \frac{K \times \theta WD}{\pi d^3} \)
\( = \frac{1.1 \times 8 \times 850 \times 40}{\pi \times (8)^3} \)
\( (\tau) = 186.01 \text{ Mpa} \)
Deflection of spring \( (\delta) = \theta \times \frac{D}{2} \)
\( \theta = \text{angular deflection} \)
\( T = \frac{\tau}{D/2} = \frac{G\theta}{L} \)
\( \theta = \frac{\tau L}{JG} \)
J = Polar moment of inertia of a spring wire

\[ J = \frac{\pi}{32} \times d^4 \]

\[ J = \frac{\pi}{32} \times 8^4 \]

J=0.785

G= modulus of rigidity of the material

Angular deflection \( \theta = \frac{\tau}{JG} \)

\[ \theta = \frac{186.01 \times 180}{0.785 \times 87500} \]

\[ \theta = 0.4874 \]

Deflection of spring \( \delta = \theta \times \frac{d}{2} \)

\[ \delta = 0.4874 \times \frac{40}{2} \]

\[ \delta = 9.74 \text{mm} \]

Similarly for other Loads

**TABULAR FORM FOR THEORITICAL VALUES**

<table>
<thead>
<tr>
<th>S.no</th>
<th>Load (N)</th>
<th>Maximum shear stress (( \tau )) MPa</th>
<th>Deflection (( \delta )) mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>850</td>
<td>186.01</td>
<td>9.74</td>
</tr>
<tr>
<td>2</td>
<td>1050</td>
<td>229.77</td>
<td>12.04</td>
</tr>
<tr>
<td>3</td>
<td>1550</td>
<td>339.19</td>
<td>17.77</td>
</tr>
<tr>
<td>4</td>
<td>2050</td>
<td>448.61</td>
<td>23.51</td>
</tr>
<tr>
<td>5</td>
<td>2550</td>
<td>558.03</td>
<td>29.24</td>
</tr>
</tbody>
</table>

**4. RESULTS AND DISCUSSIONS**

4.1 Material Properties

<table>
<thead>
<tr>
<th>Material</th>
<th>Alloy Steel</th>
<th>Chromium Vanadium Steel</th>
<th>Stainless Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield Strength</td>
<td>620.422N/mm²</td>
<td>615 N/mm²</td>
<td>172.34N/m²</td>
</tr>
</tbody>
</table>

**Tensile Strength**

<table>
<thead>
<tr>
<th></th>
<th>723.826N/mm²</th>
<th>94 N/mm²</th>
<th>513.61N/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elastic Modulus</td>
<td>210000N/m²</td>
<td>2100 N/m²</td>
<td>200000N/m²</td>
</tr>
<tr>
<td>Poisson’s Ratio</td>
<td>0.28</td>
<td>0.394</td>
<td>0.28</td>
</tr>
<tr>
<td>Mass Density</td>
<td>7700 g/cm³</td>
<td>7800 g/cm³</td>
<td>7800 g/cm³</td>
</tr>
<tr>
<td>Shear Modulus</td>
<td>79000 N/mm²</td>
<td>318.9N/m²</td>
<td>7700 N/mm²</td>
</tr>
<tr>
<td>Thermal Expansion Coefficient</td>
<td>1.3e-005 /Kelvin</td>
<td>1.18e-007 /Kelvin</td>
<td>1.1e-005 /Kelvin</td>
</tr>
</tbody>
</table>

**4.2 SIMULATIONS ON SPRING MODEL**

Material—Alloy Steel

**Fig4** shows Maximum Shear Stress for Alloy Steel at 850 N

**Fig5** shows Maximum Deflection for Alloy Steel at 850 N

**MATERIAL—CHROMIUM VANADIUM STEEL**
Fig 6 shows Maximum Shear Stress for Chromium Vanadium Steel at 850 N

Fig 7 shows Maximum Deflection for Chromium Vanadium Steel at 850 N

MATERIAL – STAINLESS STEEL

Fig 8 shows Maximum Shear Stress for Stainless Steel at 850 N

Fig 9 shows Maximum Deflection for Alloy Steel at 850 N

Below Table Shows Maximum Shear Stress and Deflection for the Above Three Material

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Load (N)</th>
<th>Maximum shear stress (τ) MPa</th>
<th>Deflection (δ) mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alloy Steel</td>
<td>850</td>
<td>185.88</td>
<td>9.12</td>
</tr>
<tr>
<td>Chromium Vanadium Steel</td>
<td>850</td>
<td>185.97</td>
<td>939.88</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>850</td>
<td>185.89</td>
<td>9.59</td>
</tr>
</tbody>
</table>

Graph 1 shows Maximum Shear Stress And
Deflection for the Three Materials.

From the above graph it shows that alloy steel material is having less stress and deflection. Now that alloy steel material is undergone analysis under different loads. Below shows analysis reports for alloy steel material at different loads.

At Load 1050 N

Fig 10 shows Maximum Shear Stress for Alloy Steel at 1050 N

Fig 11 shows Maximum Deflection for Alloy Steel at 1050 N

Similarly for other Loads

### ANALYTICAL VALUES

<table>
<thead>
<tr>
<th>S.no</th>
<th>Load (N)</th>
<th>Maximum shear stress (τ) MPa</th>
<th>Deflection (δ) mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>850</td>
<td>185.88</td>
<td>9.12</td>
</tr>
</tbody>
</table>

Comparison between Theoretical and Analytical Values for Maximum Shear Stress

<table>
<thead>
<tr>
<th>S.no</th>
<th>Load (N)</th>
<th>Maximum shear stress (τ) MPa (Analytical)</th>
<th>Maximum shear stress (τ) MPa (Theoretical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>850</td>
<td>185.88</td>
<td>186.01</td>
</tr>
<tr>
<td>2</td>
<td>1050</td>
<td>232.35</td>
<td>229.77</td>
</tr>
<tr>
<td>3</td>
<td>1550</td>
<td>346.63</td>
<td>339.19</td>
</tr>
<tr>
<td>4</td>
<td>2050</td>
<td>464.69</td>
<td>448.61</td>
</tr>
<tr>
<td>5</td>
<td>2550</td>
<td>580.87</td>
<td>558.03</td>
</tr>
</tbody>
</table>

Graph 2 Shows Comparison of Maximum Shear Stress At different loads For Theoretical and Analytical values

Comparison between Theoretical and Analytical Values for Maximum Deflection
<table>
<thead>
<tr>
<th>S.no</th>
<th>Load (N)</th>
<th>Deflection (δ) mm (Analytical)</th>
<th>Deflection (δ) mm (Theoretical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>850</td>
<td>9.12</td>
<td>9.74</td>
</tr>
<tr>
<td>2</td>
<td>1050</td>
<td>11.5</td>
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<td>22.80</td>
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<tr>
<td>5</td>
<td>2550</td>
<td>28.50</td>
<td>29.24</td>
</tr>
</tbody>
</table>

Graph 3 Shows Comparison of Maximum Deflection At different loads For Theoretical and Analytical values

5. CONCLUSION:

In this suspension spring, three different materials like alloy steel, chromium vanadium steel, stainless steel were used with a constant load of 850N. Among the above materials alloy steel material give the better stress and deformation values comparing to other two materials. Mostly prefer alloy steel material for bike suspension spring due to its material stability and ductility by observing those analysis stress and deformation values. Alloy steel material is staying stable up to load 2550N. Later, by increasing loads the stress was crossing the yield strength of the material due to that the breaking of spring will be takes place. Therefore, from the above practical results alloy steel material is more stable and gives good efficiency compared to other two material.

6. REFERENCES:


9. “wagon and carriage”.


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19. "Mitsubishi Galant", Mitsubishi Motors South Africa website
22. "MMC's new Galant.", Malay Mail, Byline: Asian Auto, Asia Africa Intelligence Wire, 16-SEP-02 (registration required)
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