Modeling and Evaluation of a Two Wheeler Suspension System for Different Loads and Materials

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ABSTRACT
A suspension system or shock absorber is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy. The shock absorbers duty is to absorb or dissipate energy. 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. The design of spring in suspension system is very important. In this work a shock absorber is designed and a 3D model is created using CATIA V5.

Structural analysis is done in ANSYS on the shock absorber by varying material for spring, Spring Steel En42J, Spring Steel En47 and Spring Steel IS4454 grade3. The analysis is done by considering loads, bike weight (130kgs), bike weight and person weight (205kgs) and bike weight and two person’s weight (280kgs). Comparison is done for three materials to verify best material for spring in shock absorber.

1. INTRODUCTION
1.1 Shock Absorber:
A shock absorber or damper is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy.

Fig.1.1: shock absorber

Description
Pneumatic and hydraulic shock absorbers commonly take the form of a cylinder with a sliding piston inside. The cylinder is filled with a fluid (such as hydraulic fluid) or air. This fluid-filled piston/cylinder combination is a dashpot.

Explanation
The shock absorber’s duty is to absorb or dissipate energy. One design consideration when designing or choosing a shock absorber is where the energy will go. In most dashpots, energy is converted to heat inside the viscous fluid.

Applications
Shock absorbers are an important part of automobile and motorcycle suspensions, aircraft landing gear, and the supports for many industrial machines. Large shock absorbers have also been used in structural engineering to reduce the susceptibility of structures to earthquake damage and resonance. A transverse mounted shock absorber, called a yaw damper, helps keep railcars from swaying excessively from side-to-side and are important in passenger railroads, commuter rail and rapid transit systems because they prevent railcars from damaging station platforms. The success of passive damping technologies in suppressing vibration amplitudes could be ascertain with the fact that it has a market size of around $4.5 billion.

Vehicle suspension
In a vehicle, it reduces the effect of traveling over rough ground, leading to improved ride quality,
and increase discomfort 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.

**Shock Absorber types**

There are a number of different methods of converting an impact collision into a relatively smooth cushioned contact.

- Metal Spring
- Rubber Buffer
- Hydraulic Dashpot
- Collapsing safety Shock Absorbers
- Pneumatic Cylinders
- Self compensating Hydraulic

**1.2.2 Types of springs**

- Helical springs
- Conical and volute springs
- Torsion springs
- Laminated or leaf springs
- Disc or Belleville springs
- Special purpose springs

**2. HELICAL SPRING**

Helical springs are made up of a wire-coiled into the form of a helix primarily intended for compressive or tensile loads.

Two types of helical spring are there:

1. Compressive helical spring and
2. Tensile helical spring

**2.1. PROBLEM DEFINITION**

When a vehicle is traveling on a level road and the wheels strike a bump, the spring is compressed quickly. The compressed spring will attempt to return to its normal loaded length and, in so doing, will rebound past its normal height, causing the body to be lifted. The weight of the vehicle will then push the spring down below its normal loaded height. This, in turn, causes the spring to rebound again. This bouncing process is repeated over and over, a little less each time, until the up-and-down movement finally stops. If bouncing is allowed to go uncontrolled, it will not only cause an uncomfortable ride but will make handling of the vehicle very difficult.

**2.2. OBJECTIVES OF THIS WORK**

The design of a spring in the suspension system is very important. In this work a shock absorber is designed and a 3D model is created using CATIA V5 Structural Analysis. The analysis is done in ANSYS on the shock absorber by varying the material for spring, Spring Steel En42J, Steel En47 and Spring Steel IS4454 grade 3. The analysis is done considering loads, bike weight (130kgs), bike weight and person weight (205kgs) and bike weight and two person’s weight (280kgs).

Comparison is done for three materials to verify the best material for the spring in the shock absorber.
3. MATERIALS USED FOR PROPERTIES AND APPLICATIONS

Spring Steel En42J

Chemical Composition

Table 3.1 Chemical Composition of Spring Steel En42J

<table>
<thead>
<tr>
<th>Element</th>
<th>Min%</th>
<th>Max%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon, C</td>
<td>0.35</td>
<td>0.90</td>
</tr>
<tr>
<td>Manganese, Mn</td>
<td>0.60</td>
<td>0.90</td>
</tr>
<tr>
<td>Silicon, Si</td>
<td>-</td>
<td>0.33</td>
</tr>
<tr>
<td>Sulfur, S</td>
<td>-</td>
<td>0.05</td>
</tr>
<tr>
<td>Phosphorus, P</td>
<td>-</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Application

En 42J is suitable for a wide range of spring applications including flat springs, clutches, knives, idoctor blades, saw blades, agricultural tools, woodcutting saws, knives, shims, washers, masonry tools.

Spring Steel En47 Material properties

Chemical Composition

Table 3.3 Chemical Composition of Spring Steel En47

<table>
<thead>
<tr>
<th>Element</th>
<th>Min%</th>
<th>Max%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon, C</td>
<td>0.45</td>
<td>0.55</td>
</tr>
<tr>
<td>Manganese, Mn</td>
<td>0.50</td>
<td>0.80</td>
</tr>
<tr>
<td>Silicon, Si</td>
<td>-</td>
<td>0.50</td>
</tr>
<tr>
<td>Chromium, Cr</td>
<td>0.90</td>
<td>1.20</td>
</tr>
<tr>
<td>Sulfur, S</td>
<td>-</td>
<td>0.05</td>
</tr>
<tr>
<td>Phosphorus, P</td>
<td>-</td>
<td>0.05</td>
</tr>
<tr>
<td>Vanadium</td>
<td>0.15</td>
<td>-</td>
</tr>
</tbody>
</table>

Application

- IS4454 grade3 materials is a good wear resistance.
- IS4454 grade3 is excellent toughness and shock resistance, and used to vehicles suspension system.

4. DESIGN OF EXPERIMENT

4.1 Introduction To Catia:

CATIA is one among the world’s leading high-end CAD/CAM/CAE software packages. CATIA (computer assisted 3 dimensional interactive application) could be a multi-platform PLM/CAD/CAM/CAE business code suite developed by Desalt systems marketed worldwide by IBM. CATIA is written within the C++ artificial language. iCATIA provides open development, design through the employment of interfaces, which might be customized.
customizable development applications. The applications in programming interfaces support visual basic and C++ programming languages. Commonly said as 3D product Lifecycle management (PLM) software system suite, CATIA supports multiple stages of development. The stages vary from conceptualization, through design (CAD) and producing (CAM), till analysis (CAE). Every workbench of CATIA V5 refers to every stage of development for various merchandise. CATIA V5 options are a constant solid/surface-based package that uses NURBS because the core is surface illustration and has many workbenches however offer KBE (knowledge primarily based engineering) support.

4.1.4 Total Assembly

![Total assembly or suspension system or shock observer](image)

**Fig.4.4: Total assembly or suspension system or shock observer**

**ASSUMPTION CALCULATIONS**

**Load calculations**

- Weight of bike: \( W = 130\text{kg} \)
- Let weight of one person: \( p_1 = 75\text{Kg} \)
- Weight of two persons: \( p_2 = 75 \times 2 = 150\text{Kg} \)
- Weight of bike and one person: \( W_1 = 205\text{Kg} \)
- Weight of bike and two persons: \( W_2 = 280\text{Kg} \)
- Rear Suspension: \( R_s = 65\% \)

- Weight of bike and one person = 205Kg
- 65% Rear Suspension of 205x0.65 = 132.25Kg
- \( W_1 = 133.25 \times 9.81 \)
- \( W_1 = 1307.18\text{N} \)

### Load on two shock absorbers

- Weight of two persons = 280Kg
- 65% Rear Suspension of 280x0.65 = 182Kg
- \( W_2 = 182 \times 9.81 \)
- \( W_2 = 1785.42\text{N} \)

For single shock absorber acting load = 1785.42/2
- \( W_2 = 892.71\text{N} \)

**Introduction To Ansys**

ANSYS is a general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements the equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be represented in tabulated or graphical forms.

This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

**ANALYSIS**

In this analysis work is done using Ansys software. Here the loads applied on the shock absorber, the loads are 205kgs and 280kgs. In analysis bottom side of the shock absorber is fixed. The loads are applied at top of the shock absorber. The material is En 42J Spring steel, En 47 Spring steel and IS 4454 Grade 3 materials.

**RESULTS**

**Table 4.1: Results Comparison**

<table>
<thead>
<tr>
<th>Materials</th>
<th>Loading (Kgs)</th>
<th>Applying 65% Rear Suspension (N)</th>
<th>Deformation (mm)</th>
<th>Stress (Mpa)</th>
<th>Strain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring steel En 47</td>
<td>205</td>
<td>653.59</td>
<td>34.401</td>
<td>573.33</td>
<td>0.0032</td>
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<tr>
<td></td>
<td>280</td>
<td>892.71</td>
<td>46.986</td>
<td>783.05</td>
<td>0.0044</td>
</tr>
<tr>
<td>Spring steel En 47</td>
<td>205</td>
<td>653.59</td>
<td>39.455</td>
<td>573.35</td>
<td>0.0034</td>
</tr>
<tr>
<td></td>
<td>280</td>
<td>892.71</td>
<td>49.455</td>
<td>783.11</td>
<td>0.0047</td>
</tr>
<tr>
<td>Spring steel IS4454 Grade 3</td>
<td>205</td>
<td>653.59</td>
<td>32.765</td>
<td>573.3</td>
<td>0.0031</td>
</tr>
<tr>
<td></td>
<td>280</td>
<td>892.71</td>
<td>44.753</td>
<td>782.99</td>
<td>0.0042</td>
</tr>
</tbody>
</table>
5. CONCLUSION

In our work we have designed a shock absorber used in a suspension system in two wheeler. We have modeled the shock absorber by using 3D parametric software Pro/Engineer. To validate the strength of our design, we have done a structural analysis on the shock absorber. Stress, strain and total deformation will be observed under expected loads. We have done an analysis by varying spring materials Spring Steel En47, Spring Steel En42J and Spring Steel IS4454 grade 3. By comparing the results for three materials, the total deformation value is less for spring steel IS4454 grade 3 than Spring Steel En47 and Spring Steel En42J. So we can conclude that as per our analysis Spring Steel IS4454 grade 3 for spring is best.