

FAULT FREQUENCY ANALYSIS OF 4-WHEELER SHOCK ABSORBER FOR COMPOSITE SPRING STEEL

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ABSTRACT:

The Shock Absorber is a part of the suspension system in a vehicle which is designed mechanically to handle shock impulse and dissipate kinetic energy. In a vehicle, it reduces the effect of travelling over rough ground, leading to improved ride quality and increase in comfort due to substantially reduced amplitude of disturbances. Frequency Response Analysis is done to determine the displacement due to cyclic loading and Transient Analysis (Shock Analysis) is done to study the performance of the Shock Absorber during shock loading. Comparison is done for four materials to verify best material for spring in Shock absorber. Also, the spring diameter has been varied based on the results to check for scope of improved performance. 3D Modelling is done in UNIGRAPHICS 10.0, Meshing is done in Hyper Mesh, OPTISTRUT for solving and Hyper view and Hypergraph for post processing and viewing the results.

Keywords: Shock absorber, fault frequency, FEM, model analysis

1.0 INTRODUCTION

Shock absorbers are a critical part of a suspension system, connecting the vehicle to its wheels. The need for dampers arises because of the roll and pitches associated with vehicle manoeuvring, and from the roughness of roads. Shock absorbers are devices that smooth out an impulse experienced by a vehicle, and appropriately dissipate or absorb the kinetic energy. A safe vehicle must be able to stop and maneuver over a wide range of road conditions. Good contact between the

tires and the road will be able to stop and maneuver quickly. Suspension is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels. Shock absorber is an important part of automotive suspension system which has an effect on ride characteristics. Shock absorbers are also critical for tire to road contact which to reduce the tendency of a tire to lift off the road. This affects braking, steering, cornering and overall stability

The springs are the separate machine elements of various configurations, having the primary function to act as a cushioning element. This means undergoing significant deflection under load, thereby absorbing energy in the form of strain energy. Helical springs are often used in mechanical systems. They can be designed in such a way that they show nonlinear behavior. This means that the spring stiffness is not constant but depends on the compression. This nonlinear behavior occurs when the number of active coils decreases or increases with varying compression. The nonlinear behavior of a spring can be achieved by

- varying the coil diameter
- varying the pitch
- varying the mean spring diameter in axial direction

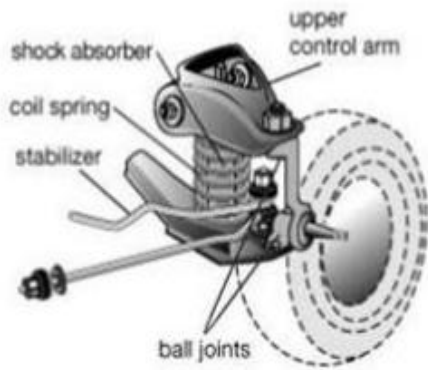


Figure: 4- wheeler suspension system

2.0 LITERATURE REVIEW

Choube AM and Wakulkar RE [1] analyzes spring, shock absorbers and linkages which connects vehicle to its wheel and allows relative motion between them are termed as suspension. Springs are helical metal coil which can be pressed or pulled but they have tendency to return to its original shape and size when released generally springs are used to absorb the shock or movement by its elastic action. Helical springs are being used in many vehicles as shock absorbers to have smooth ride, better control over vehicle, maintain correct ground clearance, and keep tires in contact with road.

Kumhar Vikky, [2] analysed the effectiveness of the shock absorber in spring frequency under load condition. The shock absorber is commonly used at all vehicles today. The purpose of this research paper is to investigate and identified the problem in shock absorber spring during ride a motor cycle on bump. After identified problem we can decreases stress, deformation and increases its frequency capability by changing its coil diameter of spring. There are some problem happen at the vehicle when ride at the bumping road condition

Choube AM, [3] deals with analysis of mono suspension by using FE approach

and validated with analytical with varying speed. Helical spring is the most common element that has been used in suspension system. In this research, helical spring related to light vehicle suspension system under the effect of a uniform loading has been studied and finite element analysis has been compared with analytical solution. Maximum stress and deflection have been compared at various speeds for carbon steel material.

Reddy Pramod M, [4] in 2014 Observe the vibrations from shock loads due to irregularities of the road surface. It is perform its function without impairing the stability, steering (or) general handling of the vehicle. Generally, for light vehicles, coil springs are used as suspension system. A spring is an elastic object used to store mechanical energy and it can be twist, pulled (or) stretched by some force and can return to their original shape when the force is released.

3.0 METHODOLOGY

In transportation vehicles, an important part of the passenger's comfort and ride comfort is the vibration to which he is subjected. Information concerning the response of passengers to a vehicle vibration environment has become increasingly important for use in the development of new transportation systems. While under design of a new system with regard to allowed vibration levels can cause it to be uncomfortable and hence unacceptable to the traveling public, overdesign (where vibrations that would normally not affect the passenger's perception of comfort significantly are eliminated) can result in excessive system cost. Indeed, in many cases system cost is very strongly related to the ride quality criteria that may be imposed upon the designer. This study is an attempt to relate

ride comfort on road vehicle to measured riding vibrations in order to evaluate some design criteria presently in use and to develop better criteria for vehicle ride comfort design The material used for leaf springs is usually a plain carbon steel having 0.90 to 1.0% carbon. The leaves are heat treated after the forming process. The heat treatment of spring steel products has greater strength and therefore greater load capacity, greater range of deflection and better fatigue properties and A composite material is made by combining two or more materials – often ones that have very different properties. The two materials work together to give the composite unique properties. However, within the composite you can easily tell the different materials apart as they do not dissolve or blend into each other

Fatigue Failure:

Failure is one of most important aspects of material behaviour because it is directly influent the selection of material for certain application, the method of manufacturing and service life of component. The majority of engineering failures are caused by fatigue. Fatigue failure is defined as the tendency of a material to fracture by means of progressive brittle cracking under repeated alternating or cyclic stresses of intensity considerably below the normal strength. Although the fracture is of a brittle type, it may take some time to propagate, depending on both the intensity and frequency of the stress cycles. Nevertheless, there is very little, if any, warning below failure if the crack is not noticed. The number of cycles required to cause fatigue failure at a particular peak stress is generally quiet large, but it decreases as the stress is increased. For some mild steels, cyclical stresses can be continued indefinitely provided the peak

stress (sometimes called fatigue strength) is below the endurance limit value.

Modeling of Helical Coil Spring:

The spring is measured to have a constant pitch and a variable diameter at its ends. The spring has a total of 12 full turns and two half turns which are flattened out to be fixed on to the Top and Bottom Mounts respectively. A helix is constructed with a constant pitch, height of 200mm and the diameters at the ends are 48mm and 44.5mm respectively. The spring wire diameter is measured to be 8mm. A circle of 8mm diameter is swept around the helix to create the basic spring. The ends of the spring are trimmed to become flat to be fixed on to the Top and Bottom Mounts respectively.

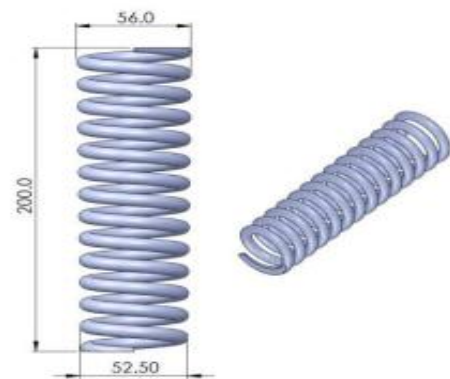


Figure: Helical Coil Spring

Assembly of Shock Absorber:

Piston Rod for the Damper is modeled similarly and the shock absorber is assembled in the Assembly module of SolidWorks as shown in the figure below

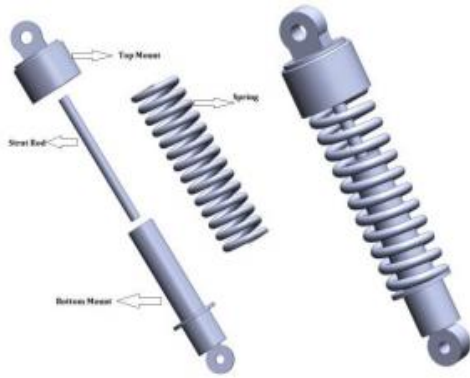


Figure: Exploded and Assembled views

4.0 Results And Discussions

Frequency response analysis is used to calculate the response of a structure to steady state oscillatory excitation. Frequency response analysis is used to compute the response of the structure, which is actually transient, in a static frequency domain. The loading is sinusoidal. The loads can be forces, displacements, velocity, and acceleration. The results from a frequency response analysis are displacements, velocities, accelerations, forces, stresses, and strains. OPTISTRUCT supports Direct and Modal frequency response analysis. Results of this analysis for the five materials selected are as follows:

Frequency response analysis:

From the mode shapes, the coil spring vibrates the most at natural frequencies. It can be explained that the coil spring will most likely to fail first before the shock absorber itself failed. Once the coil spring failed, without the spring, the shock absorber can hardly return to original position since the function of coil spring is to absorb the potential energy and helps the shock absorber to return to original position so that the wheel can always keep intact with the road.

Case-1: Stainless Steel Spring Wire as per ASTM A 313

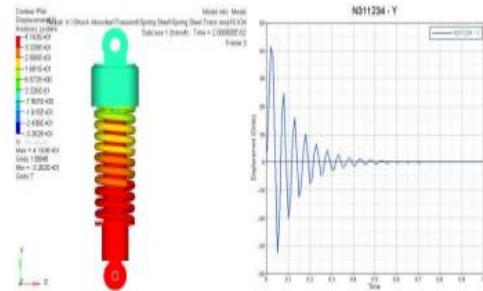


Figure: Max. Displacement 59.9mm @ 26Hz

Case-2: Cold drawn, high tensile Carbon galvanized Steel as per ASTM A 228

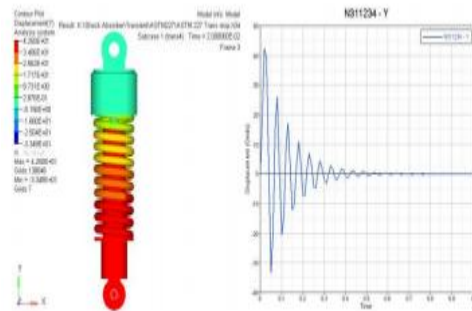


Figure: Max. Displacement 62.2mm @ 24Hz

Case-3: Phosphor Bronze Grade A Spring Wire as per ASTM B 159

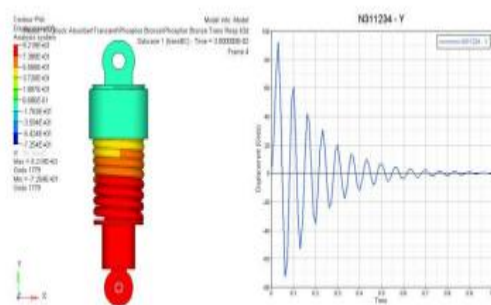


Figure: Max. Displacement 124.1mm @ 16Hz

Case-4: Beryllium Copper Spring Wire as per ASTM B 197

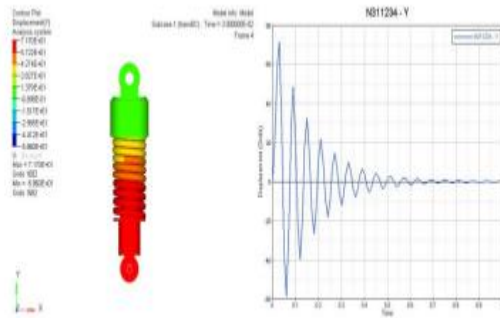


Figure: Max. Displacement 99.1mm @ 20Hz

All the analyses under Frequency Response Analysis are done by giving a unit load excitation to the bottom eye of the Shock Absorber and a cyclic load is applied. A sinusoidal load is applied in a frequency range of 0Hz to 60Hz. In the results obtained, it can be observed that the frequency at the first resonance point matches nearest to the results of first modal frequency obtained in modal analysis. This proves the accuracy of frequency response analysis and the corresponding displacements are thus obtained. From the results above, Copper Alloy based springs and titanium alloy springs have very high deflections almost near to the complete compression of the spring which is not acceptable. Spring Steel based springs are showing considerably better results but there is a scope available for improvement.

CONCLUSION:

According to this study, natural frequencies of the car shock absorber can be obtained using both calculations and simulation. In calculation, it investigated the quarter-car model of the suspension system and obtained frequency response of the model to observe how the natural frequencies effect on the system. The material of the Helical Spring was varied for five different materials and the Analyses were performed. From the

results, the following conclusions are made It is observed that, Copper based alloys and Titanium alloy-based materials for springs are not suitable for Four-Wheeler Shock Absorber applications as their spring stiffness is too less for automobile applications. Keeping all the other parameters constant, the wire diameter of the spring is increased to the next standard value and the better performing material of ASTM A 228 is selected for the modified spring. The Static deflection has reduced, which in-turn gives more displacement to be available for the spring to deflect during Shock/Impact loads. The resonant frequencies are moved to 30Hz. There are no frequencies below the low frequency ranges of 0- 20Hz. finally in this conducted, wire diameter of spring with 9.125mm and material for spring as per ASTM A 228 is found to be a better choice for the spring of the shock absorber as when compared to the existing model.

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