

Design Analysis of a Automotive Shock Absorber Assembly

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Abstract - A Shock absorber is basically an oil pump placed between the frame of the car and the wheels. The upper mount of the shock connects to the frame (i.e., the sprung weight), while the lower mount connects to the axle, near the wheel (i.e., the unsprung weight). Shock absorbers work in two cycles — the compression cycle and the extension cycle. The compression cycle occurs as the piston moves downward, compressing the hydraulic fluid in the chamber below the piston. The extension cycle occurs as the piston moves toward the top of the pressure tube, compressing the fluid in the chamber above the piston. The objective of the study is to perform the validation of the design for the effectiveness of the shock absorption for required load conditions. The suspension system is analysed for the design validation using contact nonlinear analysis to study the deflection and stress based on Abaqus software. The Static Stress Analysis is performed and maximum deflection is found due to the spring and damping arrangement. The maximum stress is found in the springs. This gives a maximum factor of safety which indicates there is further scope for weight optimisation. Modal analysis is performed to study the natural frequency of the system. The first natural frequency is found which is above the normal range of 5 Hz which indicates a stiffer suspension. So from vibration point of view also the weight can be further reduced to have softer and firm suspension.

Keywords: Shock absorber, load conditions, Abaqus software, Static Stress Analysis, contact non linear analysis, maximum stress, Modal analysis

1. INTRODUCTION

In comparable with carriages and railroad trains, most early engine vehicles used leaf springs. The principle features of these springs was that the friction between the leaves offered a degree of damping and in a 1912 review of vehicle suspension, the absence of this trademark in helical springs was the explanation it was "impossible" to utilize them as main component. At any rate the measure of damping gave by leaf spring friction was restricted and variable according to the states of the springs, and whether wet or dry. It also worked in the two bearings. Bike front suspension received coil sprung Druid forks from around 1906, and comparative structures later included turning erosion dampers, which damped the two different ways - however they were flexible (for example 1924 Webb forks). These contact circle safeguards were additionally fitted to numerous vehicles.

A suspension system or shock absorber is a mechanical assembly designed to smooth out or damp shock impulsive, and disperse the kinetic energy. In a automotive vehicle, it decreases the impact of going over harsh ground, prompting good ride quality, and rise in comfort because of considerably reduced amplitude of disturbances. At the point if a vehicle is going on a level street and the wheels strike a bump, the spring is compressed rapidly. The spring which is compressed will to return to its typical stacked length and, in this fashion, will bounce back past to its normal height, making the body be lifted. The mass of the vehicle at that point drives the spring down below its normal loaded height. This, in turn, makes the spring bounce back once more.

2. METHODS AND METHODOLOGY

2.1 Introduction

The linear static analysis is carried out for Shock absorber assembly. The stress distribution, vibration of the Shock absorber assembly is evaluated. Load conditions for every one of the tests are as commanded according to suggested standards. Static analysis doesn't consider variety of load with respect to time. In static analysis, velocity and acceleration are always zero whereas modal analysis can anticipate these factors concerning time /frequency.

Static analysis would likely show stress magnitude within yield stress as safe but in reality it might fail. Hence modal analysis becomes necessary for accessing the safety of the Shock absorber assembly structure.

2.2 Methodology

The basic step is to design the Shock absorber assembly using specification. Make a 3D model of Shock absorber assembly by utilizing solid works (solid edge) next it is imported in ABAQUS/CAE. And the next procedure is to mesh the 3D model of Shock absorber assembly using the tetra elements. Each and every component is confined finely meshed and then assembled back to its original shape. After the meshing is completed then Perform stress and modal analysis is done by using ABAQUS/standard. Then the modal analysis is done for Shock absorber assembly. The stress distribution, vibration and modal analysis of the Shock absorber assembly are calculated. Load conditions for all the tests are as mandated as per recommended standards. The linear static analysis and modal analysis to study natural frequency of the Shock absorber assembly design is evaluated.

2.3 Geometric Modeling

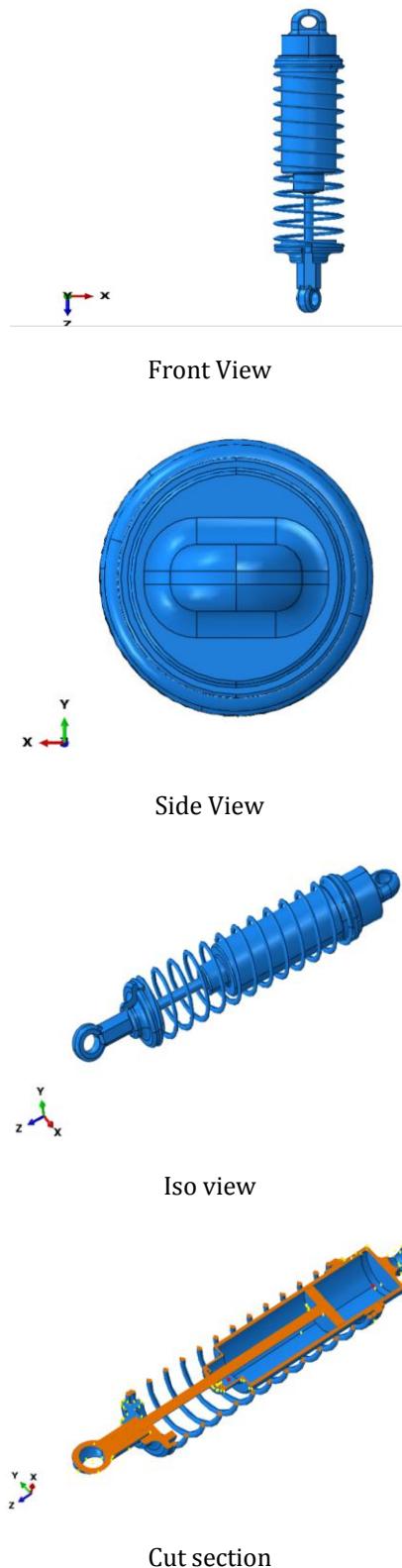


Fig 1: Typical design of Shock absorber assembly considered for analysis

The above Fig 1 gives the representation of Shock absorber assembly with representing top view, Cut section, Iso view and shows representation of side view. The modelling has been done using the modelling software, SOLID EDGE.

Model is built in solid works by 2D sketch. At that point to characterize the size and area, measurements are added to the sketch. Attributes are characterized by the relations such as perpendicularity, tangency and parallelism. Last drawings are created from parts. Based on this drawing views are created automatically and to this tolerance and dimensions are included.

2.4 FE Model Generation

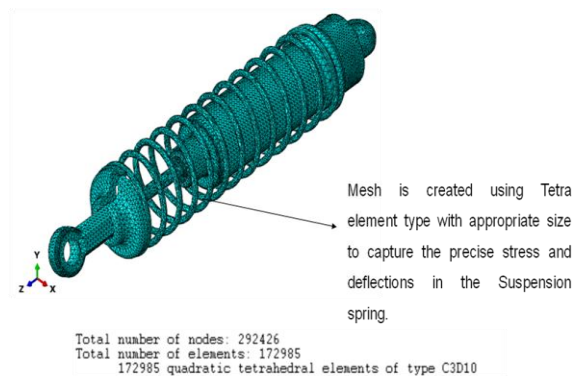
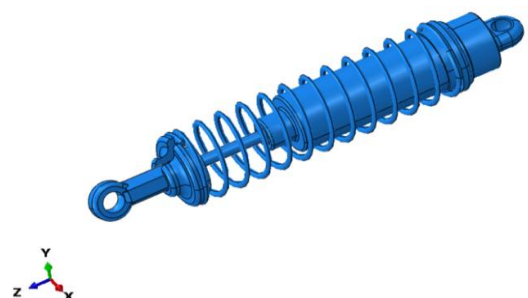


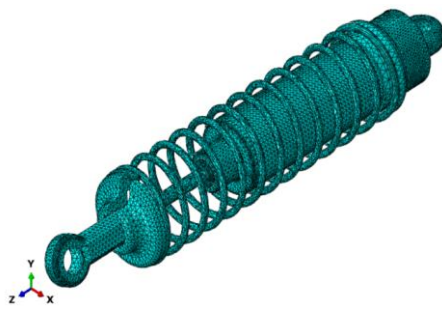
Fig 2: Finite element model of Shock absorber assembly

The FE modeling is quadratic tetrahedral elements of type C3D10 as appeared above. Each element has 4 nodes for quadratic and three nodes for triangular elements. These elements provide precise outcomes when the structure is under constant bending and membrane strain approximations. An appropriate finer element size is utilized to capture the bending and static deflection in the structure. Various elements, can replace to triangles. However, C3D10 element become stiffer than quadratic, thus C3D10 elements are utilized. Free meshing techniques are common meshing technique in ABAQUS and use hexa shell element to acquire the exact and DOF.

2.5 Meshing

Dividing the component into number of elements with a goal whenever the load is applied on the component it distributes the load uniformly.





Total number of nodes: 292426
 Total number of elements: 172985
 172985 quadratic tetrahedral elements of type C3D10

Fig 3: Shock absorber assembly meshed using tetrahedral elements

Table 1: Elements and nodes count

Total number of nodes	292426
Total number of elements	172985
Element type	Quadratic tetrahedral element

Table 1 shows the number of element and nodes generated during the discretization.

2.6 Material Property for ASTM 228_in Shock absorber assembly.

Table 2: material properties of ASTM 228

SL NO	PROPERTIES	VALUE
1	Density	7800 kg/m ³
2	Young's Modulus	210 GPa
3	Poisson's Ratio	0.313
4	Tensile yield Strength	1590 MPa

As appeared in the table no [2] above we can assume that the materials properties and the values for ASTM 228 in a Shock absorber assembly are given.

Table 3: Design Calculation for Spring

1	Material: Steel(modulus of rigidity) G	78600 MPa
2	Mean diameter of a coil D	50 mm
3	Diameter of wire d	4 mm
4	Total no of coils n1	11
5	Height h	180 mm
6	Outer diameter of spring coil D0 = D +d	54 mm

7	No of active turns n	8
8	Weight of bike	131 kgs
9	Let weight of 1 person	75 Kgs
10	Weight of 2 persons	75×2=150 Kgs
11	Weight of bike + persons	263 Kg
12	Rear Suspension	171 Kg
13	Considering dynamic loads it will be double W	342 Kg = 3355N
14	For single shock absorber weight = w/2	1677N
15	C = spring index = D/d	12.5

2.7 Loads and Boundary Conditions

Loading conditions or loads are forces, acceleration or deformations applied to a structure or its components. Loads cause deformations, displacements and stresses in structures. Mechanical structures such as satellites, aircrafts, space stations and rockets have their own structural loads and actions according to the standards of contracts or published regulations. Thorough understanding of the boundary conditions is required to get great results. The load and boundary conditions are done in this section.

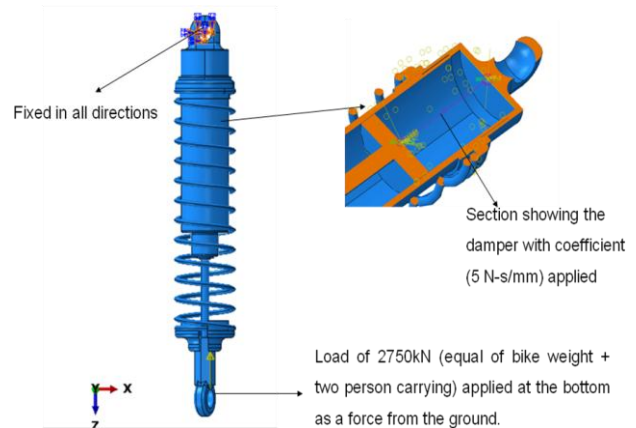


Fig 4: FEM of Shock absorber assembly and boundary condition

2.8 Types of Analysis

Static Stress Analysis

Contact Non Linear static stress analysis of Shock absorber assembly structure is carried out by utilizing ABAQUS software. Firstly the component is made using Solid Edge and is imported to ABAQUS software. The meshing of a Shock absorber assembly is completed by using the quadratic tetrahedral elements, ABAQUS is used as solver. Static stress analysis used to determine the maximum stresses induced in the Shock absorber assembly to recognize maximum compression in the design. Shock absorber assembly with

maximum compression loads is considered for future analysis.

Modal Analysis

Modular investigation is the normal attributes of the mechanical structure. Each modular demonstrates the damping ratio, natural frequency and mode shape during vibration. There are two sorts of modular investigation methods, experimental modular analysis and finding modular analysis. In the essential system modular parameters are obtained from the verifying framework information and yield movements in the test. The following system is got by the constrained component figuring. The resonance and excitation make the spring to vibrate with single or mixed modular shapes. These conditions could not be cleared up utilizing strain gauges. Including these lines, here the ABAQUS is used for examination, to choose the natural frequency and mode shape

3. RESULT AND DISCUSSION

3.1 Introduction

The analysis of the Shock absorber assembly structure was carried out with loads and boundary conditions. The results got from both static stress analysis (stresses and displacement) and modal analysis is shown below.

3.2 Static Stress Analysis

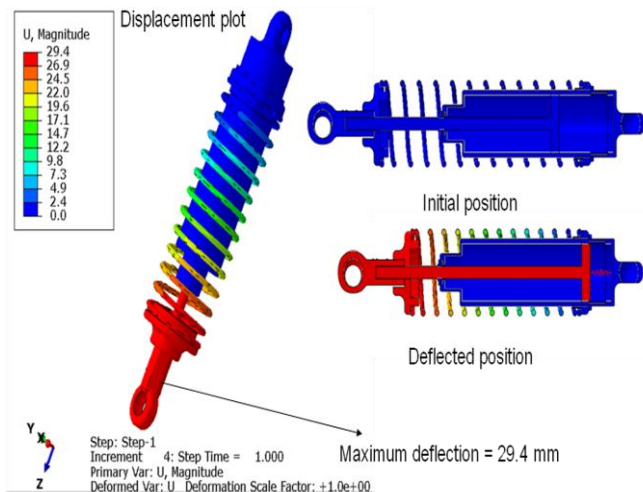


Fig 5: Maximum deflection of Shock absorbers

The static and modal analysis is done by finite element method using the ABAQUS software. For simulation of the solid works geometry. In a model when position of the node changes from the original position displacement occurs. When the loads are the applied, Fig 5 shows us the displacement for the Shock absorber assembly. From the given figure we can observe that the maximum displacement occurs at the lower end of the shock absorber. Maximum

displacement is 29.4 mm which is comes under acceptable limit.

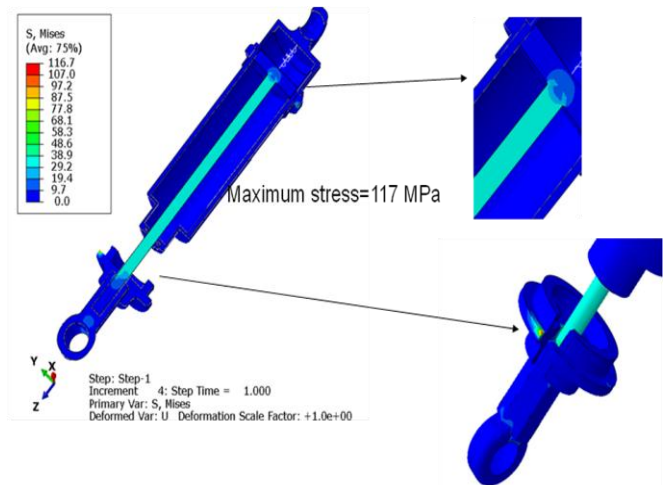


Fig 6: Maximum Stress at corner and stress at shaft of Shock absorbers

Maximum stress of 117 Mpa is observed in the corner. Shaft is experiencing about 36 Mpa.

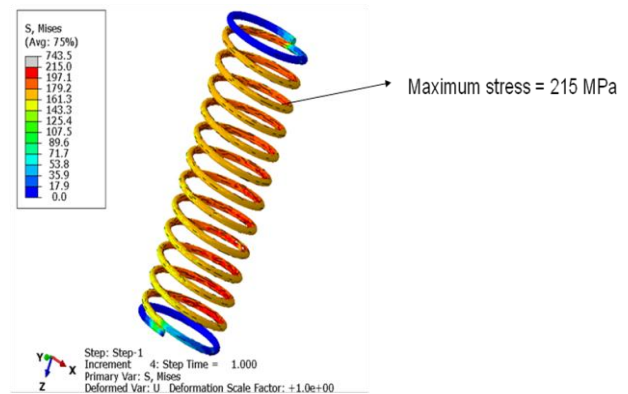


Fig 7: Maximum Stress at Spring

Maximum stress in the spring is found to be about 215 Mpa. This shows the overall it is safe and has a factor of safety of around 7.

3.3 Modal analysis

Experimental modal analysis is one of the most significant methods used to know the mode shape and natural frequency of mechanical framework. The figure shows ten different modes of vibration; in the frequency domain the dynamic properties are considered. The made model consolidated into ABAQUS solver to acquire better outcomes.

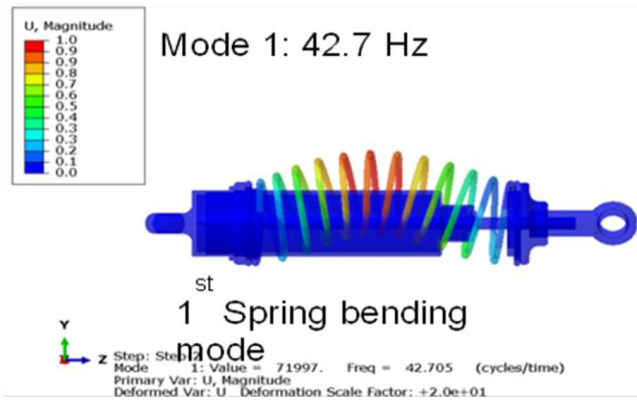


Fig 8: 1st mode of vibration

The first mode of vibration under the modal analysis is shown in Fig 8. It is 1st spring bending mode.

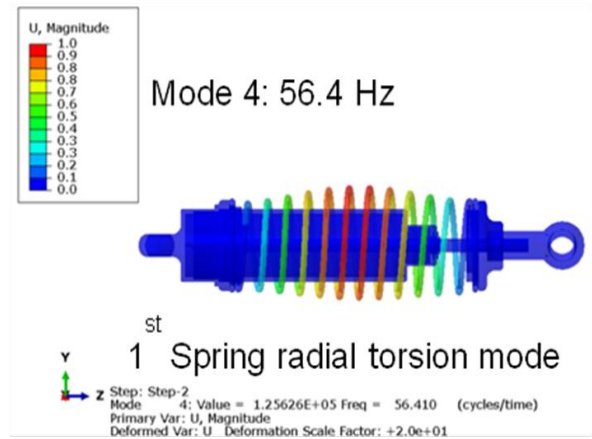


Fig 11: 4th mode of vibration

The fourth mode of vibration under the modal analysis is shown in Fig 11. It is 1st Spring radial torsion mode.

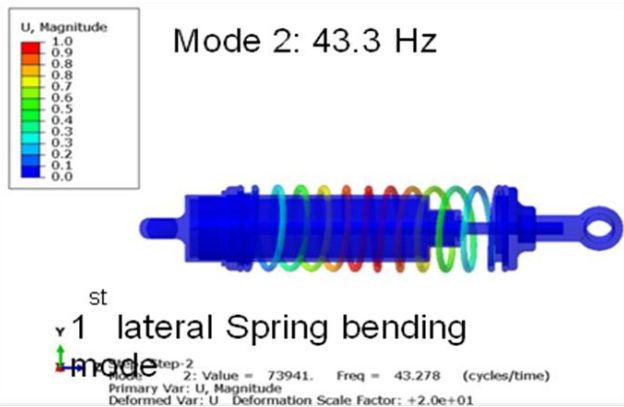


Fig 9: 2nd mode of vibration

Here, the second mode of vibration under the modal analysis is shown in Fig 9. It is 1st lateral spring bending mode.

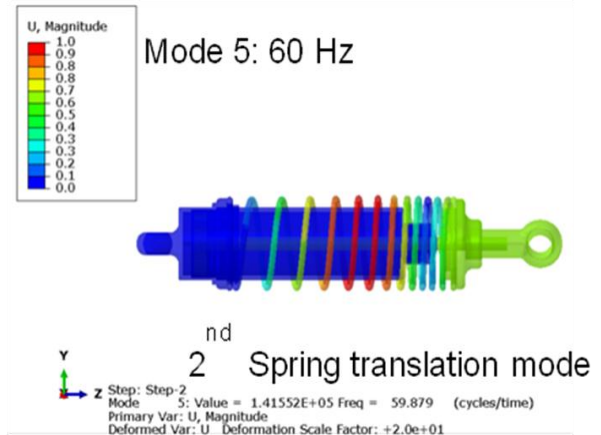


Fig 12: 5th mode of vibration

The fifth mode of vibration under the modal analysis is shown in Fig 12. It is 2nd spring translation mode.

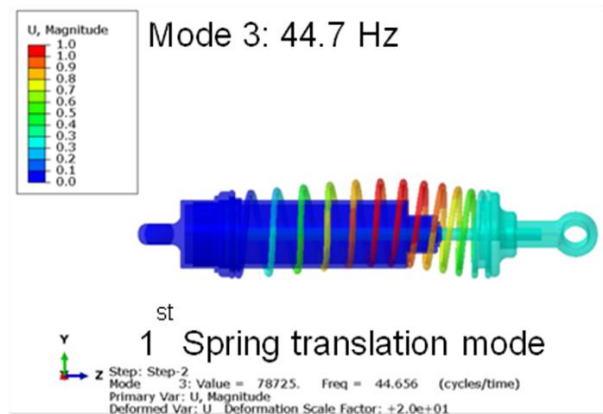


Fig 10: 3rd mode of vibration

The third mode of vibration under the modal analysis is shown in Fig 10. It is 1st spring translation mode.

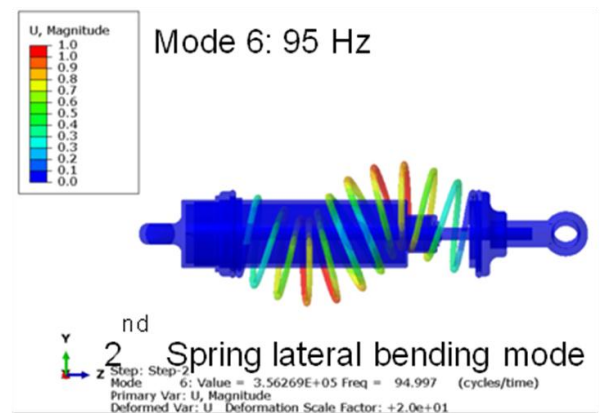


Fig 13: 6th mode of vibration

Here, the sixth mode of vibration under the modal analysis is shown in Fig 13. It is 2nd spring lateral bending mode

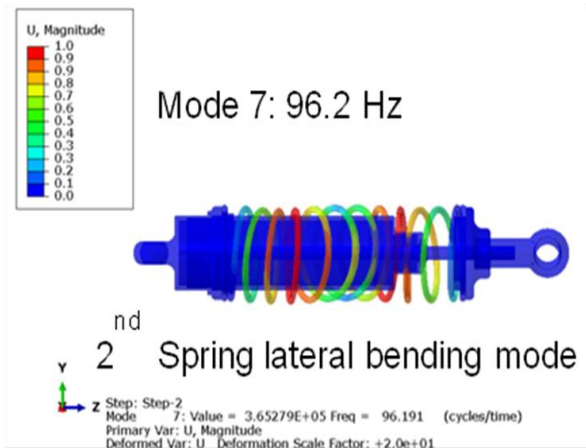


Fig 14: 7th mode of vibration

Under the modal analysis the seventh mode of vibration is shown in Fig 14. It is 2nd Spring lateral bending mode

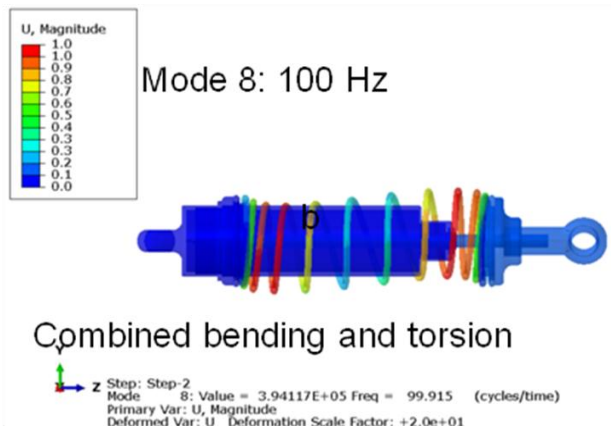


Fig 15: 8th mode of vibration

Here, the eight mode of vibration under the modal analysis is shown in Fig 15. It is combined bending and torsion

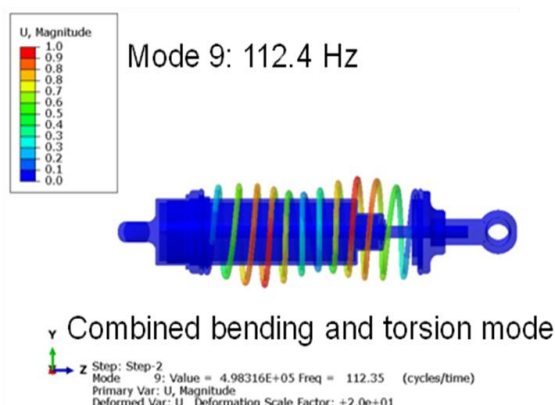


Fig 16: 9th mode of vibration

The ninth mode of vibration under the modal analysis is shown in Fig 16. It is combined bending and torsion mode

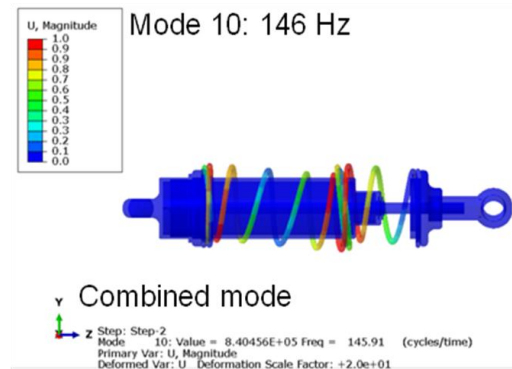


Fig 17: 10th mode of vibration

The tenth mode of vibration under the modal analysis is shown in Fig 17. It is combined mode

Experimental modal analysis is one of the most significant method used to determine the mode shape and natural frequency of mechanical system. The figure above which shows ten modes of vibration.

4. CONCLUSIONS

- The suspension system is analysed for the design validation using contact nonlinear analysis to study the deflection and stress. The maximum deflection is found to be 29.4 mm due to the spring and damping arrangement.
- The maximum stress is found 215 Mpa in the springs. This gives a maximum factor of safety of about 7 which indicates there is further scope for weight optimisation.
- Modal analysis is done to study the natural frequency of the system. The first natural frequency is found to be 42.7 Hz. This is above the normal range of 5 Hz which indicates a stiffer suspension. So from vibration point of view also the weight can be further reduced to have softer and firm suspension.

Scope of Future Work

- In future, the comfort level can be increased by measuring force transmission at both ends of helical compression spring and by decreasing the weight of shock absorber by using relevant material.
- Design analysis of the Shock absorber by changing the wire diameter of the coil spring Dynamic analysis may be applied and also changing the coil springs.
- Results are discussed as shown above and based on which conclusions are made by analysis above results we can further use these data's and experiments in future for different conditions and material.

- By changing the material and its properties to determine the stress and fatigue analysis in improved manner

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