

MODELLING AND SIMULATION OF SHOCK ABSORBERS

RAHUL PATIL^[1], B PRABHAKAR^[2]

Dept Of Mech,

Nagole Institute of Technology & Science, Hyderabad, Telangana

Abstract

Shock absorber is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic 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. In this work suspension system is designed and a 3D model is created using CATIA V5 R20. The model is also changed by changing the thickness of the spring. Structural analysis and modal analysis are done on the shock absorber by varying different spring materials. Spring materials are Spring Steel, Phosphor bronze, Beryllium Copper and Titanium alloy. To validate the strength of the model, the structural analysis on the helical spring was done. The analysis is done by considering loads, bike weight, and single, double riding. Modal analysis is done to determine the displacements for different frequencies for number of modes. Finally, comparison is done for different materials to verify best material for spring in

Shock absorber. Modelling is done in CATIA and analysis is done in ANSYS.

1. INTRODUCTION

A shock absorber or damper is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy.

1.1 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.

1.2 Explanation

The shock absorber's 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.



Fig 1. Shock absorbers

1.3 Vehicle suspension

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

(high 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 torsion 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

1.4 Shock Absorber types

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

■ Metal Spring

■ Rubber Buffer

■ Hydraulic Dashpot

■ Collapsing safety Shock Absorbers

■Pneumatic Cylinders

■Self-compensating Hydraulic

1.4.1 Metal springs

Simply locating metal springs to absorb the impact loads are a low-cost method of reducing the collision speed and reducing the shock loading. They are able to operate in very arduous conditions under a wide range of temperatures. These devices have high stopping forces at end of stroke. Metal springs store energy rather than dissipating it. If metal spring type shock absorbers are used then measures should be provided to limit oscillations. Metal springs are often used with viscous dampers. There are a number of different types of metal springs including helical springs, bevel washers (cone-springs), leaf springs, ring springs, mesh springs etc. Each spring type has its own operating characteristics.

1.4.2 Elastomeric shock absorbers

These are low cost options for reducing the collision speed and reducing the shock loading and providing system damping. They are conveniently moulded to suitable shapes. These devices have high stopping forces at end of stroke with significant internal damping. Elastomeric dampers are very widely used because of the associated advantages of low cost and mouldability

together with performance benefits. The inherent damping of elastomers is useful in preventing excessive vibration amplitude at resonance much reduced compared to metal springs. However elastomeric based shock absorbers are limited in being affected by high and low temperatures. And are subject to chemical attack. Silicone rubber is able to provide reasonable mechanical properties between temperatures of -50°C to +180°C. C- most other elastomer has inferior temperature tolerance.

1.4.3 Hydraulic Dashpot

This type of shock absorber is based on a simple hydraulic cylinder. As the piston rod is moved hydraulic fluid is forced through an orifice which restricts flow and consequently provides a controlled resistance to movement of the piston rod. With only one metering orifice the moving load is abruptly slowed down at the start of the stroke. The braking force rises to a very high peak at the start of the stroke and then falls away rapidly. On completion of the stroke the system is stable - the energy being dissipated in the hydraulic fluid as heat. This type of shock absorber is provided with springs sufficient to return the actuator to its initial position after the impacting load is removed.

1.4.4 Collapsing Safety Shock Absorbers

These are single use units which are generally specially designed for specific duties. They are designed such that at impact they collapse and the impact energy is absorbed as the materials distort in their inelastic/yield range. They therefore are more compact compared to devices based on deflections within their elastic range.

1.4.5 Air (Pneumatic) spring

These devices use air as the resilient medium. Air has a high energy storage capacity compared to metal or elastomer materials. For duties with high loads and deflections the air spring is generally far more compact than the equivalent metal or elastomer device. Due to the compressibility of air these have a sharply rising force characteristic towards the end of the stroke. The majority of the energy is absorbed near the end of the stroke. The force on an air cylinder buffer is determined by the relation $PV^n = \text{constant}$. Air springs require more maintenance than metal or elastomer-based springs and the temperature range is restricted compared to metal springs.

1.4.6 Self compensating Hydraulic

These devices are similar to the hydraulic dashpot type except that a number of orifices are provided allowing

different degrees of restriction throughout the stroke. These devices are engineered to bring the moving load smoothly and gently to rest by a constant resisting force throughout the entire shock absorber stroke. The load is decelerated with the lowest possible force in the shortest possible time eliminating damaging force peaks and shock damage to machines and equipment. These type of shock absorbers are provided with springs sufficient to return the actuator to its initial position after the impacting load is removed.

2. DESIGN CALCULATIONS FOR HELICAL SPRINGS FOR SHOCK ABSORBERS

Material: Steel (modulus of rigidity) (G) = 41000 N/mm^2

Mean diameter of a coil (D) = 62 mm

Diameter of wire (d) = 8 mm

Total no of coils (n_1) = 18 Height (h) = 220 mm

Outer diameter of spring coil (D_0) = $D + d = 70 \text{ mm}$

No of active turns (n) = 14

Weight of bike (w) = 125 Kgs

Let weight of 1 person = 75 Kgs

Weight of 2 persons = $75 \times 2 = 150 \text{ Kgs}$

Weight of bike + persons = 275Kgs

Rear suspension = 65%

65% of 275 = 165Kgs

Considering dynamic loads, it will be double

(W) = 330Kgs = 3234N

For single shock absorber weight = $(w/2) = 1617N = (W)$

Spring index $\phi = 7.75 = 8$

Solid length (Ls) = $n1 \times d = 18 \times 8 = 144 \text{ mm}$

Free length of spring (Lf)

(Lf) = solid length + maximum compression + clearance between adjustable coils

(Lf) = $144 + 282.698 + 0.15 \times 282.698$

(Lf) = 469.102

Spring rate (K) = 5.719 Pitch of coil,

Stresses in helical springs (P) = 26

Maximum shear stress induced in the wire

$(\tau) = 499.519 \text{ N/mm}^2$

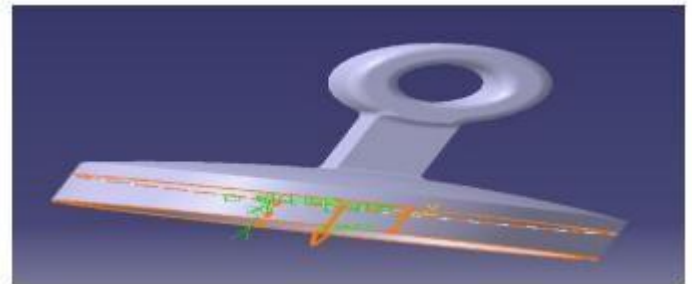
Values of buckling factor (KB) = 0.05 (for hinged and spring)

The buckling factor for the hinged end and built-in end springs (Wcr) = $5.719 \times 0.05 \times 469.102 = 134.139N$

3. DESIGN AND ANALYSIS OF SHOCK ABSORBER

3.1 CATIA

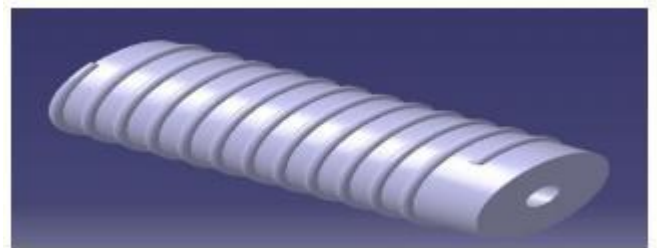
DESIGN OF UPPER MOUNT



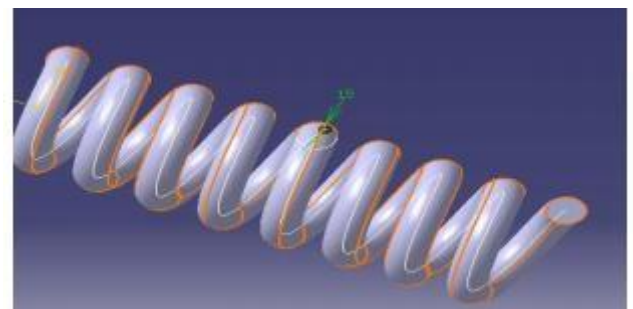
DESIGN OF BOTTOM MOUNT



DESIGN OF OIL PAD

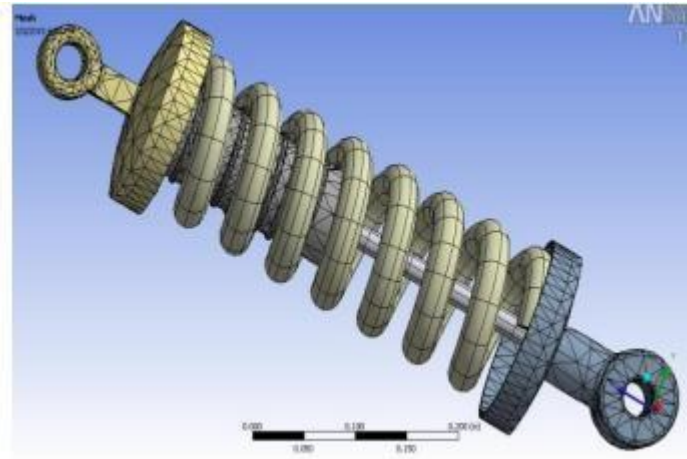
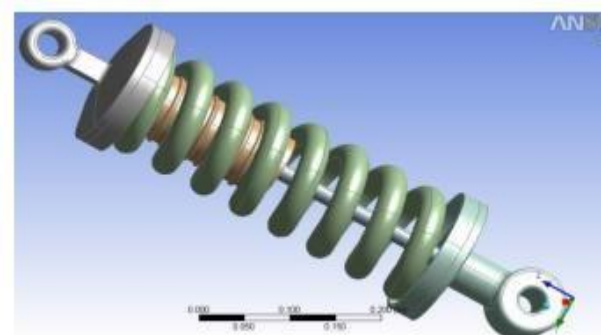


DESIGN OF HELICAL SPRING

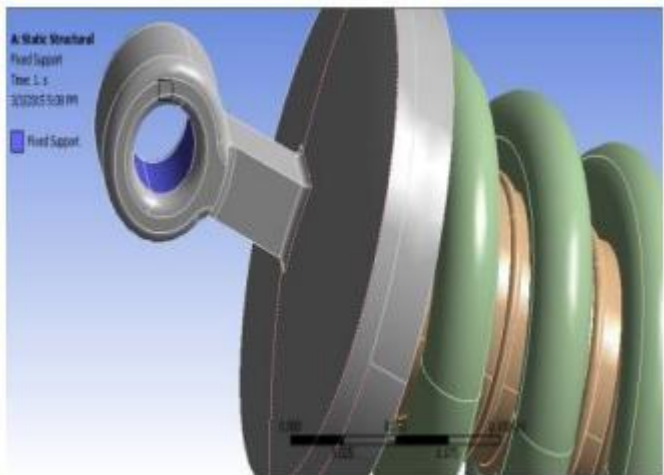


3.2 INTRODUCTION TO ANSYS

Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. This software implements 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 presented in tabulated or graphical forms.



Insert the Fixed support at one end and force of 1000 N at one end as shown below

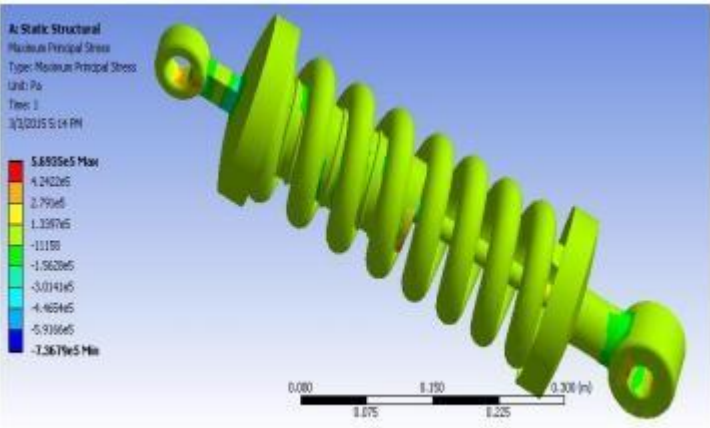


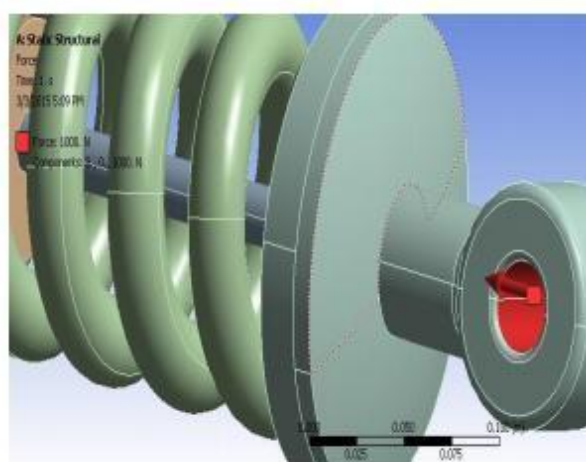
Material Properties

Sl.no	Material	Young's Modulus (N/mm ²)	Density(Kg/mm ³)
1	Spring steel	202000	7820
2	Phosphor Bronze	103000	8160
3	Copper alloy	130000	8100
4	Titanium alloy	102000	4850

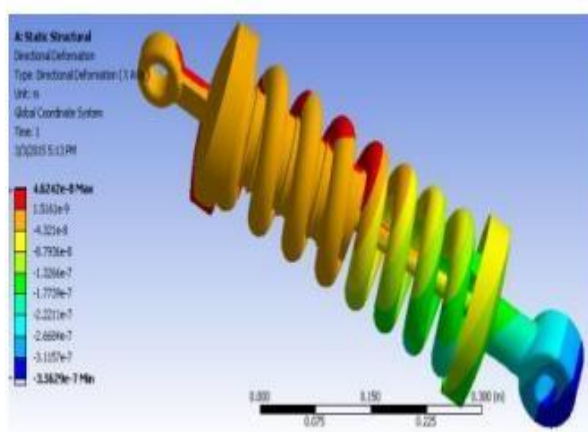
Generate the mesh of the imported component as shown below.

Directional Deformation

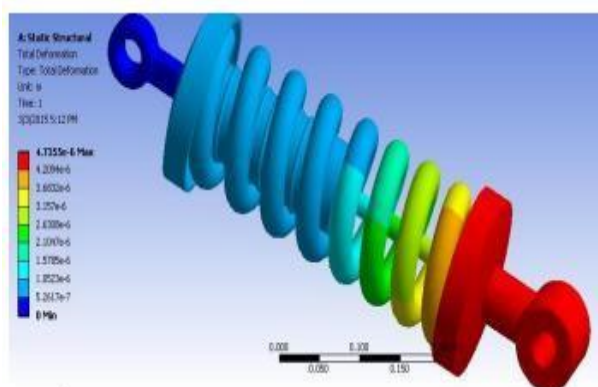




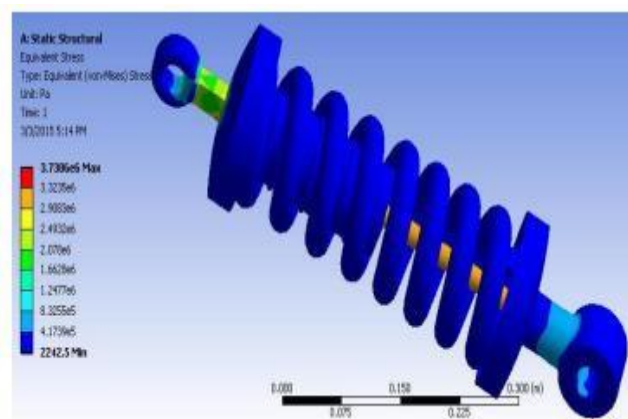
Equivalent Stress



Maximum Principal Stress



Total Deformation.



4. RESULTS AND DISCUSSION

In this project the helical spring of a shock absorber by using 3D parametric software CATIA. And also, the analysis was performed by using ANSYS is a general-purpose finite element analysis (FEA) software package. To validate the strength of the model, the structural analysis on the helical spring was done by varying different spring materials like steel, titanium alloy, copper alloy and Phosphor bronze. Modal analysis is done to determine the displacements for different frequencies for Number of modes. The maximum displacements and stress intensities of the respective materials are given below. To validate the strength of our design, we have done structural Analysis.

Sl. No	parameters	Titanium alloy	Phosphor bronze	Beryllium Copper	Spring steel
1	Maximum displacement (mm)	2.6326	4.9247	4.8582	3.0123
2	Maximum stress intensity (N/mm ²)	36.102	36.5865	36.4637	36.4265

I. Materials are Spring Steel, Phosphor Bronze, Beryllium Copper and Titanium alloy.

II. The stress intensity and displacement vectors are less for titanium alloy than other materials. So, the best material for spring is titanium alloy.

III. Also the shock absorber design is modified by reducing the diameter of spring by 2mm and structural, modal analysis is done on the shock absorber. By reducing the diameter, the weight of the spring reduces. By comparing the results for different materials, the stress value is less for Titanium alloy than Beryllium Copper, phosphor Bronze and spring steel.

IV. By comparing the results for present design and modified design, the stress and displacement values are less for modified design.

V. So we can conclude that as per our analysis using material Titanium alloy for

spring is best and also our modified design is safe.

VI. From the analysis results it is clear that the optimal stress intensities & maximum displacement values are obtained for the titanium alloy material.

VII. Therefore, when the availability of titanium alloy is more and cost of titanium material is affordable then the scope of materials for springs with titanium alloy is preferable.

5. REFERENCES

1. Machine design by R.S.KURMI
2. PSG, 2008. "DESIGN DATA," kalaikathirachachgam publishers, COIMBATORE, INDIA
3. Automobile Engineering by R.B.Gupta
4. Automobile Engineering by G.B.S. Narang.
5. Automobile Servicing and Maintenance by K.Ashraf Ali
6. Automotive Maintenance and Trouble Shooting by Ernest Venk, & Edward D. Spicer
7. www.alibaba.com
8. [En.wikipedia.org/coil springs](http://En.wikipedia.org/coil%20springs).
9. [En.wikipedia.org/history of helical spring](http://En.wikipedia.org/history%20of%20helical%20spring).
10. En.wikipedia.org/