International Journal of Research in Advent Technology, Special Issue, March 2019
E-ISSN: 2321-9637
3rd National Conference on Recent Trends & Innovations In Mechanical Engineering
15th & 16th March 2019
Available online at www.ijrat.org

Structural And Modal Analysis Of Two Wheeler Shock Absorber

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Abstract

A 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 improve ride quality, and increase in comfort due to substantially reduced amplitude of disturbances. 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.The design of spring in shock absorber is very important. In this project a shock absorber is designed and a 3D model is created using Creo. Structural analysis and modal analysis are done on the shock absorber using ANSYS software by varying material for spring (i.e.) carbon steel and beryllium copper and phosphor bronze. Structural analysis is done to validate the strength and modal analysis is done to determine the displacements for different frequencies for number of modes. After getting results from analysis comparison is done for any two materials to verify best material for spring in Shock absorber.

1. INTRODUCTION

In a vehicle, suspension system 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 torsional 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.

2. PROBLEM FORMULATION

The main purpose of shock absorber is to absorb or dissipate energy, for this a good material is required to manufacture a spring component. In this project a shock absorber is designed and a 3D model is developed using Pro/Engineer. Structural analysis and modal analysis are done on the shock absorber by varying material for spring (i.e.) carbon steel, beryllium copper and phosphor bronze. Structural analysis is done to validate the strength and modal analysis is done to determine the displacements for different frequencies for number of modes. The following data is provided for modelling and analysing

1. Part designs with dimensions.
2. Material properties having
   Young's modulus
   Poisons ratio
   Density

Actually the shock absorber consists of the following parts:

- Piston shaft
- Body
- Ball joints
- Spring

3. DESIGN CALCULATIONS

Material : Beryllium copper
Modulus of rigidity (G) = 47000 N/mm^2
Mean diameter of a coil (D) =62mm
Diameter of wire d = 8mm
Total no of coils n^1 = 18
Height h = 220mm
Outer diameter of spring coil D^0 = D +d =70mm
No of active turns n = 14
Weight of bike = 125kgs
Let weight of 1 person = 75 Kgs
Weight of 2 persons $= 75\times 2 = 150Kgs$
Weight of bike + persons = 275Kgs
Rear suspension = 65%
65% of 275 = 179Kgs
Considering dynamic loads it will be double
W = 330Kgs = 3507N
For single shock absorber weight = W/2= W = 1753.5N

We know that, compression of spring (δ) $= \frac{8W\times C^3\times n}{G\times d}$

Spring index (C) $= \frac{D}{d} = \frac{62}{8} = 7.75 = 8$

Deflection (δ) $= \frac{8\times1617\times8^3\times14}{41000\times8} = 267.427mm$

Solid length (L_s) $= n^1 \times d = 18\times 8 = 144mm$

Free length of the spring $= n^1 d + \delta_{max} + 0.15\delta_{max}$

$= 144 + 267.427 + 0.15\times 267. = 451.54mm$

Spring rate K $= \frac{W}{\delta} = \frac{1617}{267.427} = 7$

Pitch of coil P $= \frac{L_F + L_S}{n^1} = \frac{451.54-144}{18} = 26$

Stresses in helical springs: $\tau = K\times \frac{8WC}{\pi d^2}$

$K = \frac{4_C - 1}{4_c - 4} + \frac{0.615}{C}$ $= \frac{4\times8-1}{4\times8-4} + \frac{0.615}{8} = 0.97$

$\tau = K\times \frac{8WC}{\pi d^2}$ $= 0.97\times \frac{8\times1753.5\times8}{\pi\times8^2} = 660\ Mpa$

Buckling of compression springs:W_{cr} $= k\times K_B\times L_F$

K = spring rate or stiffness of spring $= \frac{W}{\delta}$

$K_B = buckling\ factor$ $= \frac{L_F}{D}$

Values of buckling factor $K_B = \frac{L_F}{D} =$ $= \frac{451.54}{62} = 7.2$

K = 0.04 (for hinged and spring)

Cripping load W_{cr} $= 7\times 0.04\times 451.54$

$= 126.43N$

4. METHODOLOGY AND APPROACH

The shock absorber model is designed for 150cc bike. The specifications of shock absorber has been taken for 150cc bike, in which required dimensions is mentioned in below.

Mean Diameter of coil (D) = 62mm
Wire Diameter of coil (d) = 8mm
Total number of coils (n^1) = 18
Height (h) = 263mm
Outer diameter of spring coil (D^0) = (D+d) = = 70mm

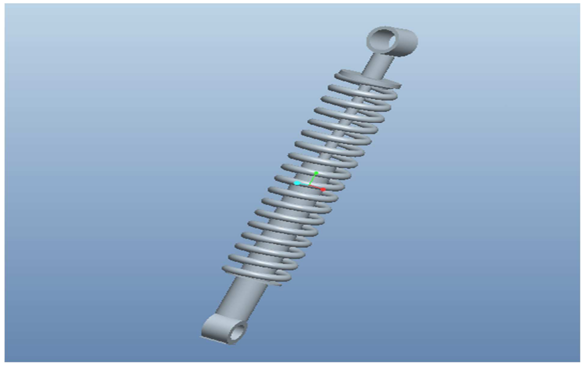

Fig. 1 Geometric Model of Shock Absorber

The geometric model of the shock absorber has been created using Creo. After the creation of the geometric model in a complete form, it is exported as an IGES file and is imported to ANSYS (A pre and post processor)

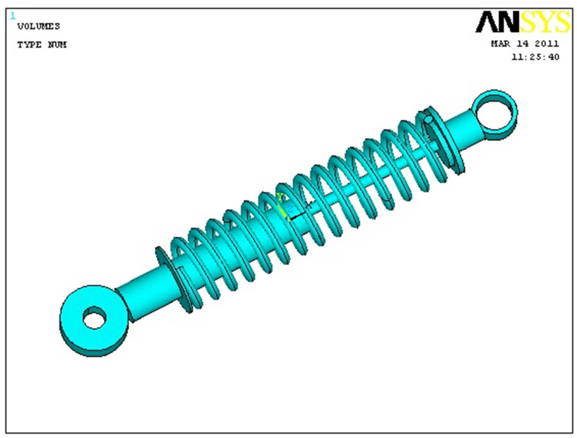

Fig. 2 Imported IGES File

Element Type : Solid 20 node 95
Stainless Steel
Material Properties : Young's Modulus (EX) : 200000N/mm^2
Poisson's Ratio (PRXY) : 0.28
Density : 0.000007612kg/mm^3

Element Type: Pipe Element
Carbon Steel
Material Properties: Young's Modulus (EX) : 210000N/mm^2
Poisson's Ratio (PRXY) : 0.29
Density : 0.000007850kg/mm^3

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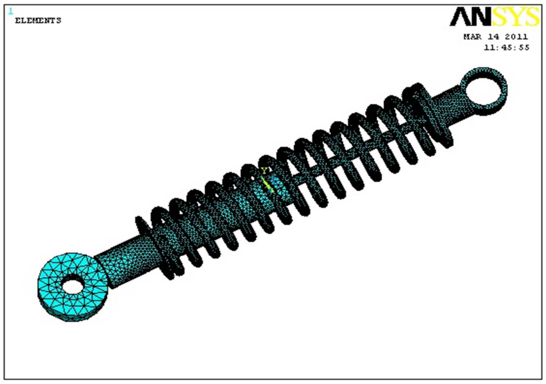

Fig. 3 Meshed Model

Normally the top eye end of shock absorber is connected to body of the vehicle and bottom eye end is connected to frame of the vehicle. Whenever the vehicle moves on uneven surface the load will be acted on top surface of the shock absorber and displacement changes occurred in bottom portion. So that for applying loads for this analysis part, by applying pressure on top surface and displacement values are applied on inner surface of bottom eye end. By applying pressure value as 0.73 N/mm^2

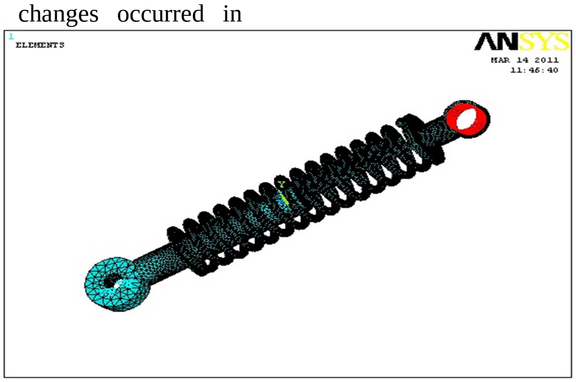

Fig. 4 Application of Loads for the model

Element Type: solid 20 nodes 95
Stainless Steel
Material Properties: Young's Modulus (EX) : 200000N/mm^2
Poisson's Ratio (PRXY) : 0.28
Density : 0.000007612kg/mm^3

Element Type: Pipe Element
Beryllium Copper
Material Properties: Young's Modulus (EX) : 115000N/mm2
Poisson's Ratio (PRXY) : 0.3
Density : 0.00000826kg/mm3

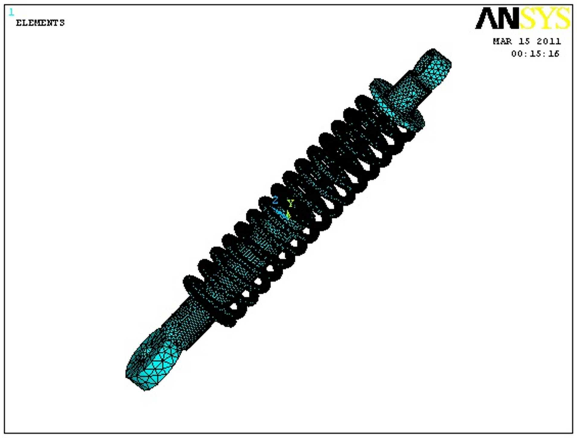

Fig. 5 Meshed Model

By applying the pressure value as 0.73 N/mm^2

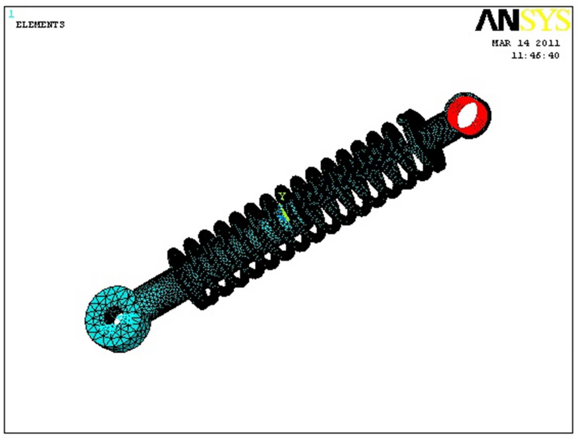

Fig. 6 Application of Loads

5. CONCLUSION

After doing analysis for two different materials, the maximum stress for carbon steel is 110.856 MPa and beryllium copper is 220.298 MPa and displacement values for carbon steel is 0.352 e $^{-4}$ and beryllium copper is 0.427 e $^{-4}$. The maximum yield stress for High Carbon Steel is 714Mpa whereas for Beryllium Copper is 725MPa. Finally the beryllium copper has high yield stress when compared to high carbon steel and the stress value obtained from analysis is less than maximum yield stress value. Now a days spring steels are used for manufacturing of springs, by performing this analysis beryllium copper can be used for manufacturing of springs.

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