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Static Structural and Fatigue Analysis of Two Wheeler Shock Absorber

Authors

Dr A.Gopichand[1], Ch. Harish Kumar[2], B. Mahesh Krishna[3], D. Bhanu Prakash[4]

[1]Professor and HOD, Department of Mechanical Engineering, Swarnandhra College of Engineering and Technology, NARASAPUR, INDIA

Email: *allakagopichand@gmail.com*

[2]P.G student, Department of Mechanical Engineering, Swarnandhra College of Engineering and Technology, NARASAPUR, INDIA

Email: *Harish.mech345@gmail.com*

[3]Assistant Professor, Department of Mechanical Engineering, Swarnandhra College of Engineering and Technology, NARASAPUR, INDIA

[4]Associate Professor, Department of Mechanical Engineering, Swarnandhra College of Engineering and Technology, NARASAPUR, INDIA

Abstract

A shock absorber or a suspension system is a mechanical device used to absorb shock loads and dissipate kinetic energy. Shock absorbers are used to reduce 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 project a shock absorber is designed and a 3D model is created using Pro/Engineer. Structural analysis and fatigue analysis are done to by varying the materials as structural steel; chrome vanadium and AISI steel 1050. In this project a shock absorber is designed and a 3D model is created using Pro/Engineer and the analysis is made by using FINATE ELEMENT ANALYSIS (FEM). Structural analysis and fatigue analysis are carried on the spring by varying the materials as structural steel, chrome vanadium and AISI 1050 steel. Comparison is made by between the simulation, analytical and experimental values for deflection and maximum shear stress.

Keywords: *shock absorber, shock loads, coil spring, fatigue analysis, structural analysis.*

1. Introduction

Shock absorbers were first introduced in French in 1898 by a cyclist J. M. M. Truffault. It has a front fork suspension with spring and a device to minimize the vibrations. Shock absorbers are an important part of automobile and motorcycle suspensions, aircraft landing gear, and the supports for many industrial machines. 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. 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.

Figure 1: shock absorber

Achyut P. Banginwar in his project a model of shock absorber is designed and 3D modeled using Pro/Engineer. Structural and modal analysis is done on the shock absorber by varying the material for the spring to spring steel and phosper bronze. Comparison is done between the two materials to verify the best material of the two for the design of the spring. [1] Mr. Sudarshan Martande the author has designed the shock absorber and modeled it and analyzed it at different loads. In this the analytical values of the stress are lower than the allowable limit. [2] Prince Jerome Christopher J the shock absorber is designed and modeled using pro/engineer. The analysis is done by changing the diameter of the spring coil at different varying loads to validate the strength of the spring. The analysis is done by considering the mass of the bike and by varying the number of persons seated on the bike. The comparison is made by varying the wire diameter of the coil spring to verify the best dimensions for the spring. [3] Pinjarla.Poornamohan the shock absorber is designed and modeled using pro/engineer. The analysis is done by changing the diameter of the spring coil at different varying loads to validate the strength of the spring. The analysis is done by considering the mass of the bike and by varying the number of persons seated on the bike. The comparison is made by varying the wire diameter of the coil spring to verify the best dimensions for the spring. [4]

2. Design and analysis of shock absorber:

Shock absorber is modeled in PRO/E. The spring is modeled by using helical sweep and the covers are modeled using extrude command. All the modeled parts are assembled using assembly module. Then the assembled parts are saved in IGS format and imported to Finite Element Analysis. In FEM Software the IGS format is imported. Materials properties are given to the individual part i.e. the spring are selected and structural steel properties are given to it. Now the reaming parts are selected and given different material properties. Now mesh the geometry as free mapped mesh and structural analysis and fatigue analysis is done by fixing the bottom end of the spring and force is applied at the top end. Now by solving the structure the deflection, von misses stress and fatigue life are noted.

2.1 Compression test:

Helical spring of the shock absorber is fitted on the UNIVERSAL TESTING MACHINE (UTM) and compression test is made on the spring and deflections are studied. The axial testing of the spring was performed on universal testing machine (UTM) having a capacity 400 KN. Load is applied uniformly and deflection are noted.

Fig 2: compression test of spring

The deflection of spring under UTM is compared with analyzing the spring using Finite Element Analysis software and analytical method

Table 1: comparison for load and deflection

	Applied Load (N)	Deflection (mm)
Simulation	**1555.84**	**94.97**
Experimental	**1500**	**89**
Analytical method	**1555.84**	**100**

2.2 Design and analysis of helical spring of shock absorber:

In this project we have modeled the shock absorber using PRO/ENGINEER software and the spring of the shock absorber is converted into IGS format and this file is imported to Finite Element Analysis software and the spring is meshed and fatigue and static analysis are done. The main comparison is made to find out the static strengths of the spring

In this work the helical spring is designed for a two wheeler shock absorber using this design parameters and the analytical analysis are done.

2.3 Dimensions of the spring:

Major diameter of the spring D_O =48 mm

Minor diameter of the spring D_I =41 mm

Diameter of the spring coil d = 7 mm

Mean diameter of the spring D $=\frac{DO + DI}{2} = \frac{48+41}{2}$ =44.5 mm

Free length of the spring = 210 mm

Number of coils n = 19

Number of active coils n^1 = 17

Let the weight of the bike =104 Kg

Let weight of a person = 70 Kg

Take G =0.8 * 10^5 N/mm^2

Weight of bike and single person = weight of bike + weight of single person

= 104 + 70 =174 Kg

Weight of bike and two persons = weight of bike + weight of two persons

= 104 +140 =244 Kg

Taking rear suspension as 65%

65% of 104 Kg = 67.6 Kg

65% of 174 Kg = 113.1 Kg

65% of 244 Kg = 158.6 Kg

Considering dynamic loads, the loads will be double.

W_1= 67.6 * 2 =1350.2 Kg *9.81 = 1326.31 N

W_2 = 113.1 * 2= 226.2 Kg *9.81 = 2219.02 N

W_3 = 158.6 * 2 = 317.2 Kg *9.81 =3111.73N

For single shock absorber, the load will be W/2.

$$W_1 = \frac{1326.31}{2} = 663.155 \text{ N}$$

$$W_2 = \frac{2219.02}{2} = 1109.51 \text{ N}$$

$$W_3 = \frac{3111.73}{2} = 1555.865 \text{ N}$$

Spring index C $= \frac{D}{d} = \frac{44.5}{7} = 6.35$

Solid length of spring $L_S = n^1 * d$

= 19 * 7 =133 mm

Spring rate K $= \frac{4C-1}{4C-4} + \frac{0.615}{C}$ =1.232

Spring deflection at load 663.15 N

$$\delta = \frac{8*W*C^3*n}{G*d} = 41.23 \text{ mm}$$

Spring deflection at load 1109.51 N

$$\delta = \frac{8*W*C^3*n}{G*d} = 68.99 \text{ mm}$$

Spring deflection at load 1555.65 N

$$\delta = \frac{8*W*C^3*n}{G*d} = 96.74 \text{ mm}$$

Maximum shear stress $\tau = K \frac{8*W*C}{\pi * d^2}$

Shear stress at a load 663.15 N

$$\tau = 1.232* \frac{8*663.15*6.35}{\pi*7^2} = 269.6 \text{ N/mm}^2$$

Shear stress at a load 1109.51 N

$$\tau = 1.232* \frac{8*1109.51*6.35}{\pi*7^2} = 451.08 \text{ N/mm}^2$$

Shear stress at a load 1555.86 N

$$\tau = 1.232* \frac{8*1555.86*6.35}{\pi*7^2} = \text{ N/mm}^2$$

The spring is modeled in PRO/ENGINEER using helical sweep command and the bottom and top cover of the spring are modeled using extrude command. (Fig 3)

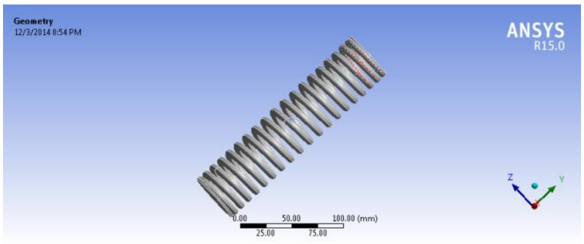

Figure 3: Spring of shock absorber

The modeled spring is imported into Finite Element Analysis software by converting it into IGS file. The imported file is opened in FEM software and meshed using face sizing mesh tool (fig 4)

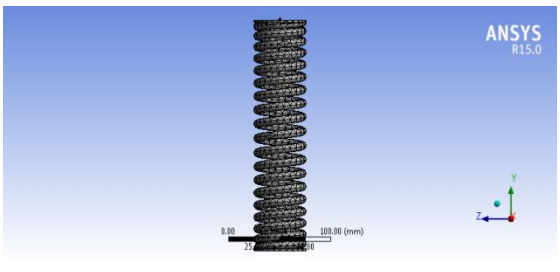

Figure 4: Meshing

The deflections obtained by in the simulation analysis. (Fig 5)

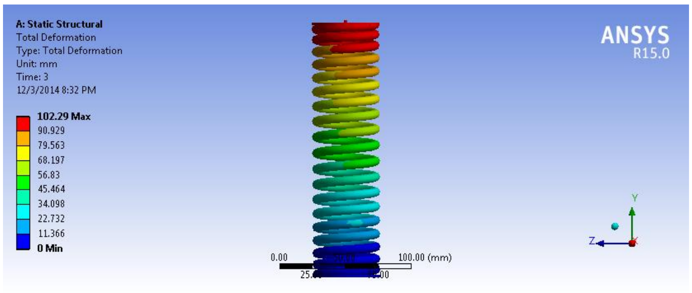

Figure 5: Total deflection

The von-mises stress obtained during the simulation analysis. (fig 6)

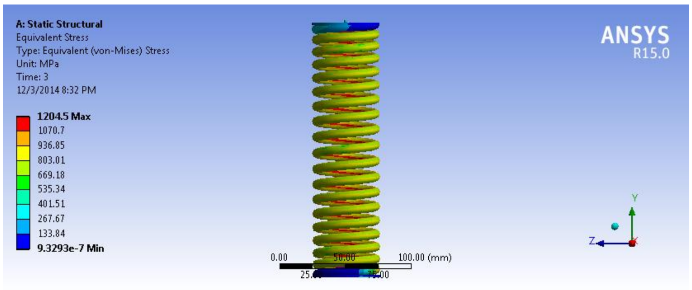

Figure 6: Equivalent stress (von-mises stress)

The factor of safety during the simulation analysis.(fig 7)

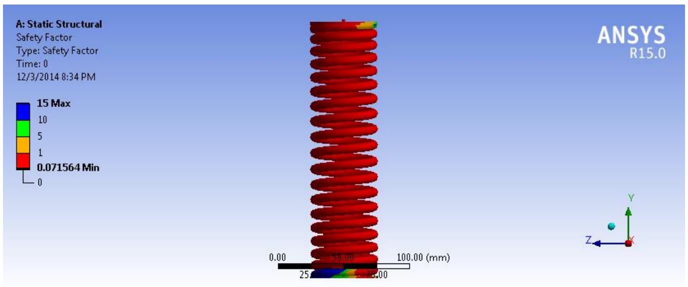

Figure 7: Factor of safety

The life of the spring during is simulation. (Fig 8)

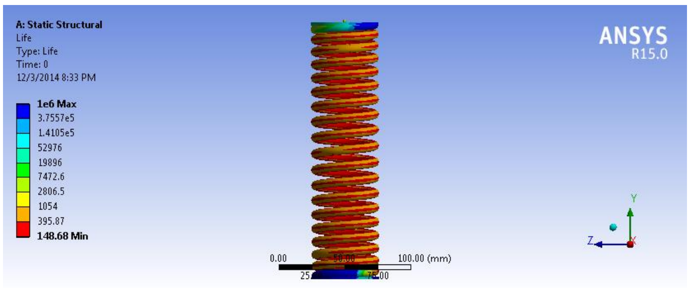

Figure 8: Life of spring

The maximum shear stress during the simulation (fig 9)

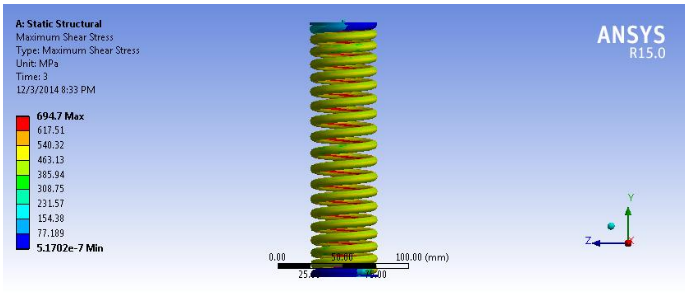

Figure 9: Maximum shear stress

In the FEM analysis the load is applied on the top face of spring at this point. (Fig 10)

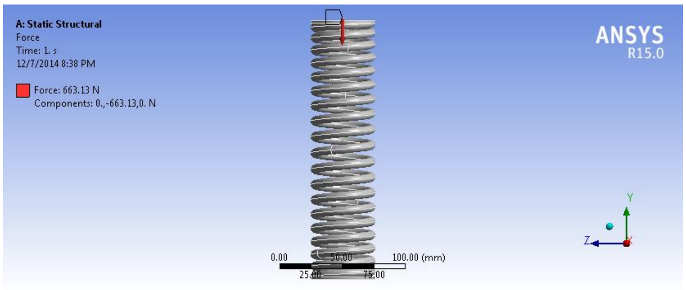

Figure 10: Load applied

In the FEM analysis the bottom plate of the spring is fixed.(fig 11)

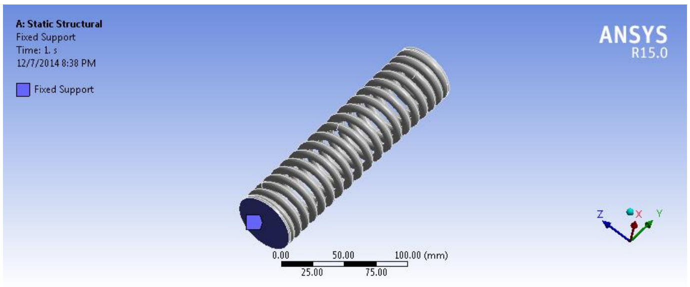

Figure 11: Fixed supports

The assembled view of the shock absorber that is used in the two wheeler. (Fig 12)

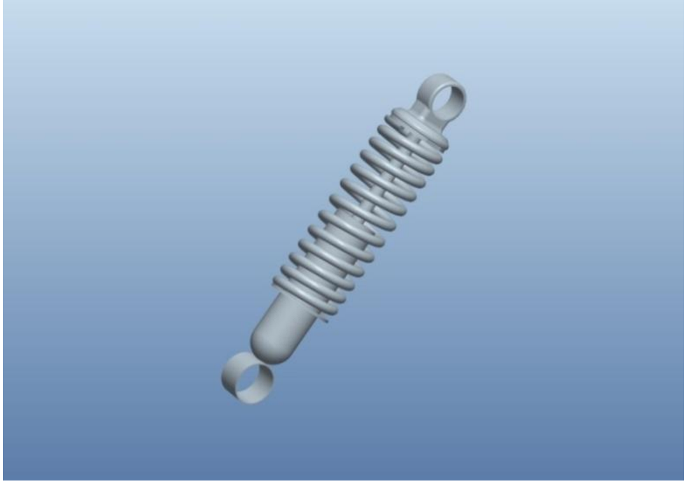

Figure 12: Shock absorber

3. Results and conclusion :

3.1 Result:

The deflections and the maximum shear stress for the materials structural steel, AISI 1050 steel and chrome vanadium steels are tabulated and the errors for the analytical and simulation analysis are done. The error at the maximum load for the materials are for structural steel is 1.63% for deflection, for AISI 1050 steel is 1.88% and for chrome vanadium is 0.317 %. The shear stress for the materials at different loads is 9.88%.

Table 2: Comparison of results

	APPLIED LOAD (N)	DEFLECTION (mm)		ERROR (%)	MAX SHEAR STRESS (N/mm^2)		ERROR (%)	LIFE (cycles)
		SIMULATION	ANALYTICAL		SIMULATION	ANALYTICAL		
STRUCTURAL STEEL	663.13	40.48	42.89	1	296.09	269.46	9.88	1347
	1109.54	67.73	71.7	1.67	495.39	450.86	9.87	353.24
	1555.84	94.98	100.64	1.63	694.7	632.23	9.88	148.68
AISI 1050 STEEL	663.13	40.73	41.51	1.87	296.09	269.46	9.88	*
	1109.54	68.15	69.46	1.88	495.39	450.86	9.87	*
	1555.84	95.56	97.4	1.88	694.7	632.23	9.88	*
CHROME VANADIUM	663.13	41.46	41.59	0.04	296.09	269.46	9.88	*
	1109.54	69.38	69.59	0.301	495.39	450.86	9.87	*
	1555.84	97.29	97.6	0.317	694.7	632.23	9.88	*

3.2 Load Vs deflection curve:

The deflections obtained for different loads are plotted for both the analytical analysis and simulation analysis.

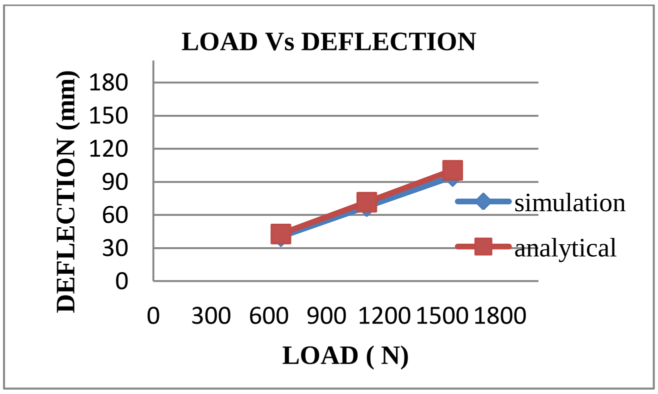

Figure 13: Load Vs Deflection curve for structural steel

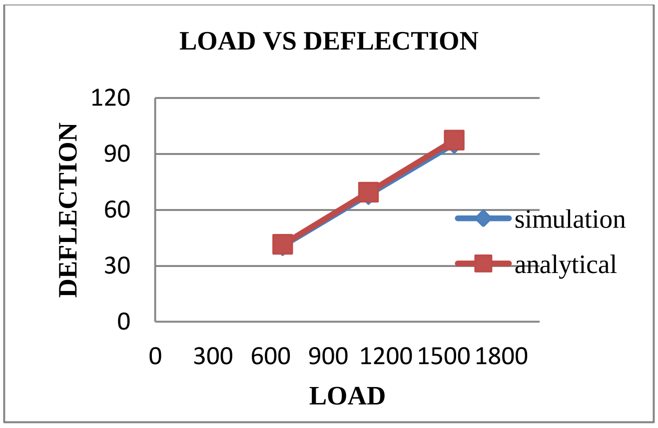

Figure 14: Load Vs Deflection curve for AISI 1050 steel

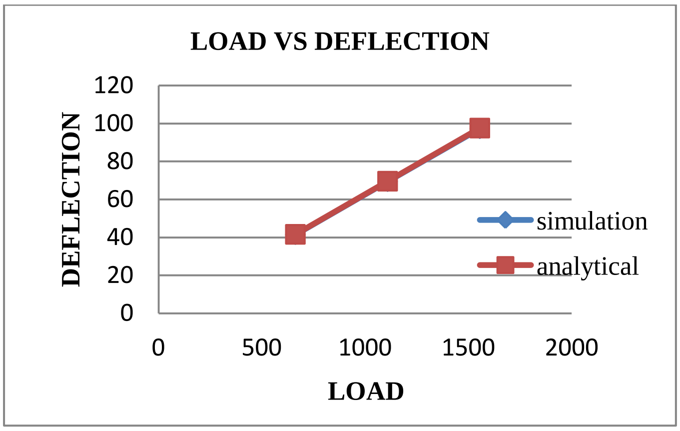

Figure 15: Load Vs Deflection curve for chrome vanadium steel

3.3 Conclusion

In this project we have done the fatigue analysis of the spring by assigning structural steel for the spring and found the life of the spring and structural analysis are also done with same material to find the strength of the spring. The main comparison is made to find the strength of the spring by varying the materials such as AISI 1050 steel and Chrome Vanadium Steel and it is found that chrome Vanadium has better strength than the other two materials. Fatigue analysis is carried out for the structural steel material and life is found out at different loads.

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Author Profile

CH.HARISH KUMAR, student Swarnandhra College of engineering & technology, Jawaharlal Nehru Technological University- Kakinada, Narsapur, West Godavari district Andhra Pradesh.

Email:*harish.mech345@gmail.com*