IMPACT: International Journal of Research in Engineering & Technology (IMPACT: IJRET)
ISSN(P): 2347-4599; ISSN(E): 2321-8843
Vol. 4, Issue 7, Jul 2016, 41-54

DESIGN AND ANALYSIS OF HELICAL SPRINGS IN TWO WHEELER SUSPENSION SYSTEM

K.VINAY KUMAR[1], R.RUDHRA ABHI RAMU[2] & CH. SIVA RAMA KRISHANA[3]

[1]PG Student, Department of Mechanical Engineering,

Vignan's Institute of Information Technology, Visakhapatnam, Andhra Pradesh, India

[2,3]Associate Professor, Department of Mechanical Engineering,

Vignan's Institute of Information Technology, Visakhapatnam, Andhra Pradesh, India

ABSTRACT

The present work is carried out on modeling and analysis of suspension spring is to replace the existed steel helical spring used in popular two wheeler vehicle. The stress and deflections of the helical spring is going to be reduced by using the new materials. The comparative study is carried out between existed spring and new material spring. Static analysis determines the stress and deflections of the helical compression spring in finite element analysis. The analytical modal is used to test the spring under different loading conditions. Finite element analysis methods (FEA) are the methods of finding approximate solutions to a physical problem defined in a finite region or domain. FEA is a mathematical tool for solving engineering problems. In this the finite element analysis values are compared to the analytical values and are successfully validated. A typical two wheeler suspension spring is chosen for study. The modeling of spring is developed on pro/E 5.0 analysis is carried out on Ansys 14.

KEYWORDS: Helical Compression Spring, Stress, Deflection, Analysis, Proe-5, Ansys 14

INTRODUCTION

The suspension system is the main part of the vehicle, where the shock absorber is designed mechanically to handle shock impulse and dissipate kinetic energy. In a vehicle, shock absorbers reduce the effect of traveling over rough Ground, leading to improved ride quality and vehicle handling. While shock absorbers serve the purpose of limiting excessive suspension movement, their intended sole purpose is to damp spring oscillations. Hysteresis is the tendency for otherwise elastic materials to rebound with less force than was required to deform them. Hence, the designing of suspension system is very crucial. In modeling the time is spent in drawing the coil spring model and the front suspension system, where risk involved in design and manufacturing process can be easily minimized. So the modeling of the coil spring is made by using SOLID WORKS. Later the model is imported to ANSYS for the analysis work.

Figure 1: Spring Suspension System

Spring Suspension System

The shock absorbers 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. The spring suspension system is shown in Figure.1

Front Suspension

Motorcycle's suspension serves a dual purpose: contributing to the vehicle's handling and braking, and providing safety and comfort by keeping the vehicle's passengers comfortably isolated from road noise, bumps and vibrations. The typical motorcycle has a pair of fork tubes for the front suspension. The most common form of front suspension for a modern motorcycle is the telescopic fork. Other fork designs are girder forks, suspended on sprung parallel links and bottom leading link designs. Some manufacturers used a version of the swinging arm for front suspension on their motocross designs. The top of the forks are connected to the motorcycle's frame in a triple tree clamp which allows the forks to be turned in order to steer the motorcycle.

Vehicle Suspension

Figure 2: Vehicle Suspension System

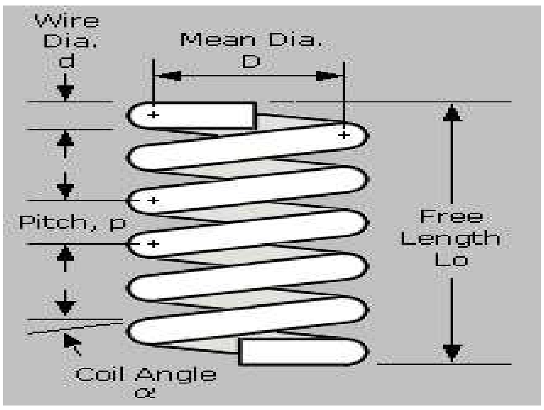


Figure 3: Dimensions of the Helical Spring

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 (higher rate) springs, which would in turn give a harsh ride. The dimensions of helical spring are detailed in Figure 3. 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 un sprung 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 tensional 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. The vehicle suspension system used is shown in figure.2

Introduction to Solid Works

Solid works mechanical design automation software is a feature-based, parametric solid modeling design tool which advantage of the easy to learn windows graphical user interface. We can create fully associate 3-D solid models with or without while utilizing automatic or user defined relations to capture design intent.

Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allow them to capture design intent.

Different Modules in Solid Works

The different modules in solid works are 1.Part Design 2.Assembly 3.Drawing 4.Sheetmetal and 5.Analysis.By using the solid works software was designed the 3D model of solid and spring because compared to the other 3D software's solid works is easy to design.

Introduction to Ansys

Many problems in engineering and applied science are governed by differential or integral equations. The solutions to these equations would provide an exact, closed form solution to the particular problem being studied. However, complexities in the geometry, properties and in the boundary conditions that are seen in most real world problems usually means that an exact solution cannot be obtained in a reasonable amount of time. They are content to obtain approximate solutions that can be readily obtained in a reasonable time frame and with reasonable effort. The FEM is one such approximate solution technique.

The FEM is a numerical procedure for obtaining approximate solutions to many of the problems encountered in engineering analysis. In the FEM, a complex region defining a continuum is discretised into simple geometric shapes called elements. The properties and the governing relationships are assumed over these elements and expressed mathematically in terms of unknown values at specific points in the elements called nodes. An assembly process is used to link the individual elements to the linked system. When the effects of loads and boundary conditions are considered, a set of linear or nonlinear algebraic equations is usually obtained. Solution of these equations gives the approximate behavior of the continuum or system. The continuum has an infinite number of degrees of freedom (DOF), while the discredited model has a finite number of DOF. This is the origin of the name, finite element method.

LITERATURE REVIEW

For providing the best design of spring coil to the suspension system of two wheeler vehicles, a lot of technical papers and review processes is studied before deciding the most feasible process for the work..The following list presents a gist of the main papers referred throughout the work Dr A.Gopichand, et.al [1] In this a shock absorber is designed and a 3D model was developed in PROE. Later structural and static analysis was done 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.

N.Lavanya et.al [2] The present work is optimum design and analysis of a suspension spring for motor vehicle subjected to static analysis of helical spring the work shows the strain and strain response of spring behaviour will be observed under prescribed or expected loads and the induced stress and strains values for low carbon structural steel is less compared to chrome vanadium material also it enhances the cyclic fatigue of helical spring.

Kommalapati. Rameshbabu, et.al [3] In this project they have designed a shock absorber used in a 150CC bike and modeled the shock absorber by using 3D parametric software Pro/Engineer. To validate the strength of design, structural analysis and modal analysis on the shock absorber was done. The analysis was done by varying spring material Spring Steel and Beryllium Copper. By observing the analysis results, the analyzed stress values are less than their respective yield stress values. The design is safe, by comparing the results for both materials, the stress value is less for Spring Steel than Beryllium Copper. 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 both materials, the stress value is less for Spring Steel than Beryllium Copper. By comparing the results for present design and modified design, the stress and displacement values are less for modified design. So they concluded that as per our analysis using material spring steel for spring is best and also their modified design is safe.

C.Madan Mohan Reddy et.al [4] the comparative study has been carried out in between the theoretical values to the experimental values and the analytical values. The maximum shear stress of chrome vanadium steel spring has 13-17% less with compare to hard drawn steel spring. The deflection pattern of the chrome vanadium steel spring 10%less at specified weight with compare to the hard drawn steel spring. It is observed that 95% of the similarity in deflection pattern and 97% similarity in shear stress pattern between experimental values to the analytical values. It is observed that 60%similarity in between theoretical values of deflection to the experimental values and 85% similarity in maximum shear stress of spring.

METHODOLOGY

Design Procedure

Spring Specifications

Spring wire diameter (d) =8 mm,

Coil mean diameter (D) =40 mm,

End Connections for Compression Helical Spring

Having following four conditions

- Plain ends.
- Ground ends.
- Square ends.
- Squared and Grounded ends.

For this design of spring Plain ends condition were taken

Total number of turns (n) =12,

No of active turns (n) = 12

Solid Length (L_s) = (n+1) d

Were n = no of active turns

d = diameter of the spring wire

(L_s) = (12+1) 8 =104 mm

Free length (L_F) = n x d + (n-1)

(L_F) = 12 x 8 + (12-1)

(L_F) = 107 mm

Pitch of the coil (p) $= \frac{Lf - Ls}{n} + d$

$= \frac{107 - 104}{12} + 8$

(p) = 2 mm

Theoretical Calculations

Let the weight of the bike = 104kg

Let the weight of the person = 65kg

Weight of bike and single person

= 104 + 65 =169 kg

Weight of bike and two persons

=104 + 65 + 65 = 234 kg

Taking Rear Suspensions as 65%

65% of total bike weight $= \frac{104X65}{100}$ = 67.6kg

65% of total bike weight + Single person

65% of total bike weight $= \frac{104X65}{100}$ = 67.6kg

65% of total person weight $= \frac{65X65}{100}$ = 42.625kg

Now 65% of total bike weight + Single person

= 67.6 + 42.625

= 110.225 kg

65% of total bike weight + two persons

65% of total bike weight $= \frac{104X65}{100}$ = 67.6kg

65% of total two person's weight

$= \frac{130X65}{100}$ = 84.5kg

Now 65% of total bike weight + two persons

= 67.6 + 84.5

= 152.1 kg

While considering the dynamic load

W_1 =67.6x2 =135.2kg

=135.2x9.81

=1326.31 N

W_2 = 110.225x2 =220.45kg

=220.45x9.81

=2162.61 N

W_3 = 152.1x2 =304.2kg

=304.2x9.81

=2984.20 N

For single shock absorber the load will be W/2

$W_1 = \frac{1326.31}{2}$

W_1 = 663.155 N

$W_{2} = \frac{2162.61}{2}$

W_2= 1081.305 N

$W_{3} = \frac{2984.20}{2}$

W_2= 1492.1 N

Were $W_{1=}$ total bike weight

$W_{2=}$ total bike weight + one person

$W_{2=}$ total bike weight +two person's

Now for Carbon Steel material at load W_1 =663.15 N. The Maximum Shear Stress and Deflection is

Spring Index, $(C) = \frac{D}{d} = \frac{40}{8} = 5$

Whal's Stress Factor $(K) = \frac{4C-1}{4C-4} + \frac{0.615}{C}$

$(K) = \frac{4(5)-1}{4(5)-4} + \frac{0.615}{5}$

(K) = 1.32

Maximum Shear Stress $(\tau) = \frac{K \times 8WD}{\pi d^3}$

$= \frac{1.32X8X663.155X40}{\pi X(8)^3}$

$(\tau) = 174.1$ N/mm^2 =174.1Mpa

Deflection $(\delta) = \frac{8WD^3 n}{Gd^4}$

$= \frac{8X663.155X40^3X12}{80000X(8)^4}$

$(\delta) = 12.43$ mm

Similarly for Carbon Steel material at load

W_2 =1081.305N. The Maximum Shear Stress and deflection is.

(τ) =283.95 MPa

(δ) =20.27 mm

Similarly for Alloy Steel material at load

W_2 =1466.59N. The Maximum Shear Stress and deflection is.

(τ) =391.83MPa

(δ) =27.97 mm

Model of Helical Suspension Spring in Solid Works

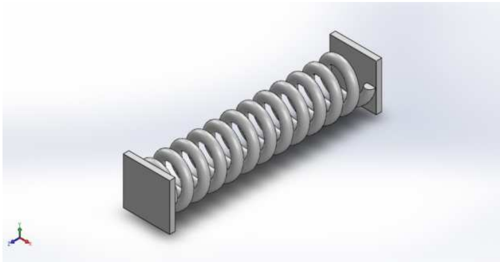


Figure 4: Spring Model in Solid Works

The Modal Developed is shown in Figure 4 for Analysis

Analysis Steps

The steps needed to perform an analysis depend on the study type. You complete a study by performing the following steps:

- Create a study defining its analysis type and options.
- If needed, define parameters of your study. A parameter can be a model dimension, material property, force value, or any other input.
- Define material properties.
- Specify restraints and loads.
- The program automatically creates a mixed mesh when different geometries (solid, shell, structural members etc.) exist in the model.
- Define component contact and contact sets.
- Mesh the model to divide the model into many small pieces called elements. Fatigue and optimization studies use the meshes in referenced studies.
- Run the study.
- View results.

RESULTS AND DISCUSSIONS

Simulations on Spring Model

Material—Carbon Steel

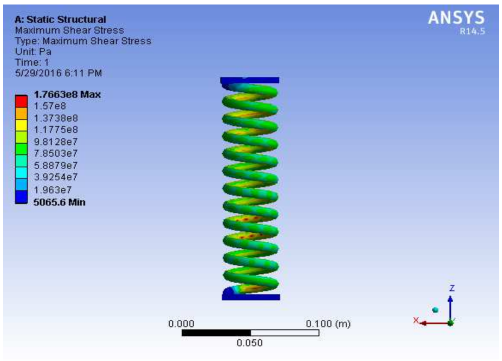


Figure 5: Shows Maximum Shear Stress for Alloy Steel at $W_{1} = 663.15N$

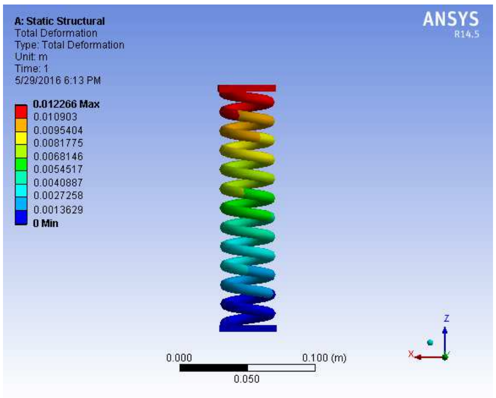


Figure 6: Shows Maximum Deflection for Alloy Steel at $W_{1} = 663.15N$

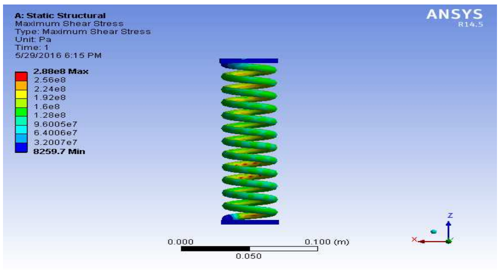


Figure 7: Shows Maximum Shear Stress for Alloy Steel at $W_{2} = 1081.305N$

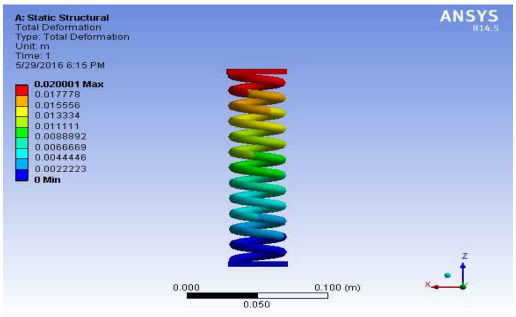


Figure 8: Shows Maximum Deflection for Alloy Steel at $W_{2} = 1081.30N$

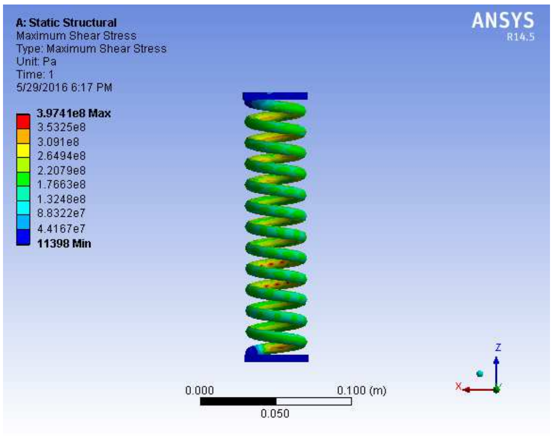


Figure 9: Shows Maximum Shear Stress for Alloy Steel at $W_3 = 1492.1N$

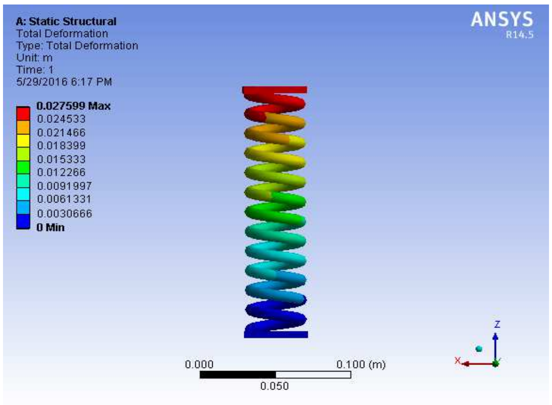


Figure 10: Shows Maximum Deflection for Alloy Steel at $W_3 = 1466.59N$

Comparison between Theoretical and Analytical Values

Comparison of Maximum Shear Stress at different loads between Analytical and Simulation values is shown in the below table.1

Table 1: Comparison of Maximum Shear Stress between Analytical and Simulation Values

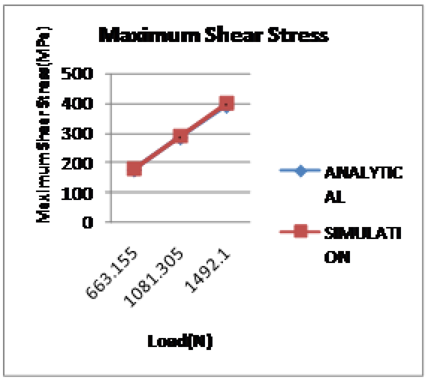
S.No	Load (N)	Maximum shear stress (τ) MPa (Analytical)	Maximum shear stress (τ) MPa (Simulation)	(%) Error
1	663.15	174.14	176.63	1.34
2	1081.30	283.95	288	1.40
3	1492.1	391.83	397.4	1.43

Comparison of Maximum Deflection at different loads between Analytical and Simulation values is shown in the below table.2

Table 2: Comparison of Maximum Deflection between Analytical and Simulation values

S.No	Load (N)	Deflection (δ) mm(Analytical)	Deflection (δ) mm (Simulation)	(%) Error
1	663.15	12.43	12.26	1.36
2	1081.30	20.27	20	1.33
3	1492.1	27.97	27.59	1.35

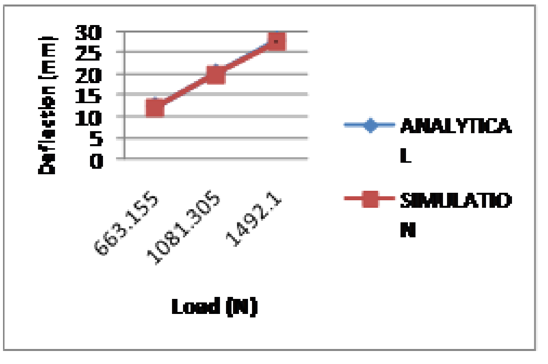
Comparison of Maximum Shear Stress between Analytical and Simulation values is shown in Graph.1



Graph 1: Load versus Max. Shear Stress

From graph1 above, it is shown that Maximum Shear Stress for Analytical and Simulation values for three different loads. The values appeared nearly same in both conditions but with some percentage error.

Comparison of Maximum Deflection between Analytical and Simulation values is shown in Graph.2



Graph 2: Load versus Deflection

From graph.2 it is shown that Maximum Deflection for Analytical and Simulation values at three different loads. The values appeared nearly same in both conditions but with some percentage error. Next simulation of spring model had under gone with other two materials like Stain less Steel and Chromium Vanadium Steel material. The results were executed below. Comparison of Maximum Shear Stress with different materials at different loads in simulation is shown in the below table.3

Table 3: Comparison of Maximum Shear Stress between Three Different Materials

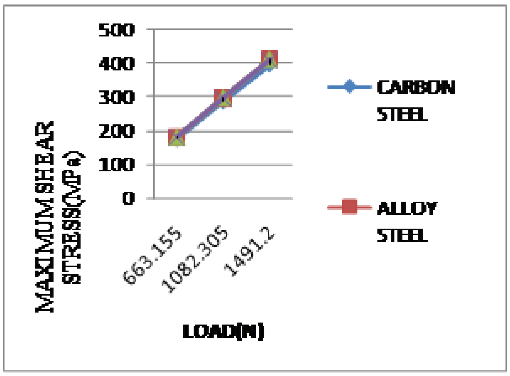
Load (N)	663.15	1081.30	1492.1
Maximum shear stress (τ) MPa (Carbon Steel)	176.63	288	397.4
Maximum shear stress (τ) MPa (Alloy Steel)	182.86	298.16	411.43
Maximum shear stress (τ) MPa (Stainless Steel)	182.92	298.26	411.57
Maximum shear stress (τ) MPa (Chromium Vanadium Steel	182.48	297.56	410.59

Comparison of Maximum Deflection at different loads between Three different materials is shown in the below table.4

Table.4 Comparison of Maximum Shear Stress between Three Different Materials

Load (N)	663.15	1081.3	1492.1
Maximum Deflection (δ) mm (Carbon Steel)	12.26	20	27.59
Maximum Deflection (δ) mm (Alloy Steel)	13.62	22.22	30.66
Maximum Deflection (δ) mm (Stainless Steel)	12.35	20.14	27.8
Maximum Deflection (δ) mm (Chromium Vanadium Steel	71.37	116.38	160.9

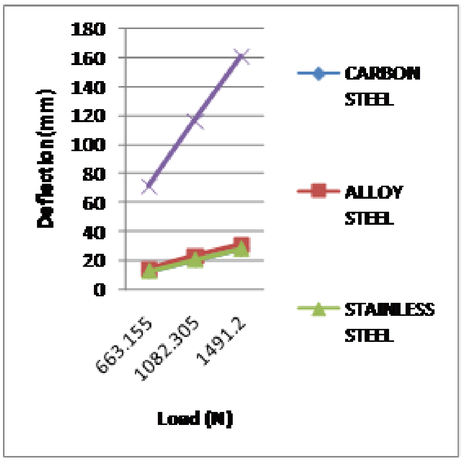
Comparison of Maximum Shear Stress between Three different materials is shown in Graph.



Graph 3: Load Versus Max. Shear Stress (Carbon Steel& Alloy Steel)

From graph3 it is show that Maximum Shear Stress for Carbon Steel is more at different loads while compare with Alloy Steel, Stainless Steel and Chromium Vanadium Steel material

Comparison of Maximum Shear Stress between Three different materials is shown in Graph



Graph 4: Load Versus Deflection 9Carbon Steel, Alloy Steel & Stainless Steel)

From graph4 it is shown that Maximum Deflection for Carbon Steel is more at different loads while compare with Alloy Steel, Stainless Steel and Chromium Vanadium Steel material.

CONCLUSIONS

- In this suspension spring, four different materials like carbon steel, alloy steel, chromium vanadium steel, stainless steel with three different loads are used for analysis. Among the above materials carbon steel material give the better stress and deformation values comparing to other three materials.

- Mostly prefer carbon steel material for bike suspension spring due it its material stability, ductility and resilience by observing those analysis stress and deformation values.
- It is also concluded, analytical values are compared with simulated valued and are well validated due to percentage of error is very low.
- Therefore, it is conclude that from the above simulation results carbon steel material is more stable and gives good efficiency compared to other three material properties.

REFERENCES

1. DrA.Gopichand,Ch.Harishkumar *"Static Structural and Fatigue Analysis of Two Wheeler Shock Absorber"* International Journal of Emerging Trends in Science and Technology IJETST- Vol.|1,Issue10,Pages1627-1633.
2. N.Lavanya, P.Sampath Rao, M.Pramod Reddy "*Design and Analysis of A Suspension Coil Spring For Automotive Vehicle,"* Int. Journal of Engineering Research and Applications www.ijera.com ISSN: 2248-9622, Vol. 4, Issue 9,, September 2014, pp.151-157.
3. Kommalapati.Rameshbabu, Tippa Bhimasankara Rao "*Design Evaluation of a Two Wheeler Suspension System for Variable Load Conditions"* International Journal of Computational Engineering Research, | Vol, 03,Issue, 4.
4. Reza N. Jazar (2008). Vehicle Dynamics: Theory and Applications. Spring. p. 455.
5. Suspension Basics 1 - Why We Need It". Initial Dave. Retrieved 2015-01-29.
6. Adams, William Bridges (1837). English Pleasure Carriages. London: Charles Knight & Co.
7. Suspension Basics 3 - Leaf Springs". Initial Dave.
8. "Wagon and carriage".
9. "The Washington Times, Sunday 30 June 1901". Chroniclingamerica.loc.gov.
10. Jain, K.K.; Asthana, R.B. Automobile Engineering. London: Tata McGraw-Hill. pp. 293–294. ISBN 0-07-044529-X.
11. "Suspension Basics 4 - Torsion Bar Springs". Initial Dave.
12. "Suspension Basics 5 - Coil Springs". Initial Dave.
13. "Suspension Basics 6 - Rubber Springs". Initial Dave.
14. "Suspension Basics 8 - Air Springs". Initial Dave. Retrieved 2015-01-29.
15. "Suspension Basics 9 - Hydro pneumatic springs". Initial Dave.
16. "Mitsubishi Motors history 1981-1990", Mitsubishi Motors South Africa website