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"DESIGN, ANALYSIS & OPTIMIZATION ON SHOCK ABSORBER SPRING"

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ABSTRACT

A Shock absorbers are a critical part of a suspension system, connecting the vehicle to its wheels. The main function of vehicle suspension system is to separate the vehicle body and passengers from the oscillation created by the irregularities and to provide continuous contact of vehicle's wheel from the road surface. 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. In this project, we are going to design a spring in such a way that it can be of different materials we have used three materials for spring namely stainless steel, titanium alloy and copper alloy. The spring is divided in three parts vertically and the sequence of arrangement of materials is changed and results are calculated in analysis software at last the best result is optimized and best solution of arrangement of materials is found out.

Keywords*: Finite Element Analysis, Shock Absorber, Solid Modelling, Suspension.*

I. INTRODUCTION

A suspension system or shock absorber is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy .In this project a shock absorber is designed and a 3D model is created using Pro/Engineer. 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 material for spring, Spring Steel and Beryllium Copper. The analysis is done by considering loads, bike weight, single person and 2 persons. Structural analysis is done to validate the strength and modal analysis is done to determine the displacements for different frequencies for number of modes. Comparison is done for two materials to verify best material for spring in Shock absorber. Modeling is done in Pro/ENGINEER and analysis is done in ANSYS. Pro/ENGINEER is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design. ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements.

[1] A shock absorber or damper is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy. 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 fluidfilled piston/cylinder combination is a dashpot.[1]

[2] A shock absorber is a mechanical device designed to smooth out or damp shock impulse, and dissipate energy. The shock absorbers duty is to absorb or dissipate energy. In a vehicle, it reduces the effect of travelling over rough ground, leading to improved quality, and increase in comfort due to substantially reduced amplitude of disturbances.[2]

[3] The mechanical device which is designed to absorb, smooth out the shock impulse during running of a vehicle is called as shock absorber. In a motor vehicle, shock absorber reduces the effect of traveling over rough ground, tends to increase the running condition, and increase in comfortness, reduced the frequency of disturbances. A sliding piston inside a cylinder which is filled with a fluid (such as hydraulic fluid) or air called as hydraulic or pneumatic shock absorbers respectively. The shock absorbers is mainly for absorb or dissipate energy. For an automobile suspensions, aircraft landing gear, and the supports of many industrial machines, the shock absorbers are very

important.. The structures from earthquake damage and resonance, shock absorbers plays vital role. Without shock absorbers, the vehicle would have a bouncing ride, as energy is stored in the spring and then released to the bike, depends on the allowed range of suspension movement. Control of excessive suspension movement or over load without shock absorption requires strong (higher rate) springs, which would in turn give a harsh ride. Shock absorbers accept the use of soft (lower rate) springs against the controlling rate of suspension movement in response to bumping. [3].

[4] The current world-wide production of shock absorbers, is difficult to estimate with accuracy, but is probably around 50– 100 million units per annum with a retail value well in excess of one billion dollars per annum. A typical European country has a demand for over 5 million units per year on new cars and over 1 million replacement units. The US market is several times that and India is not behind these countries for demand and consumption of shock absorbers. If all is well, these shock absorbers do their work quietly and without fail. Drivers and passengers simply want the dampers to be trouble free. In contrast, for the designer they are a constant interest and challenge. The need for dampers arises because of the roll and pitches associated with vehicle/bike maneuvering and from the roughness of roads. In India, road quality is generally below average and poor for smaller towns. As there is growing demand for quality shock absorbers in India, design and construction of shock absorbers are demanding tasks that require advanced calculations and theoretical knowledge [4].

[5] A shock absorber or damper is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy. 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. The shock absorbers duty is to absorb or dissipate energy. These are an important part of automobile suspensions, aircraft landing gear, and the supports for many industrial machines. Large shock absorbers have also been used in structural engineering to reduce the susceptibility of structures to earthquake damage and resonance. A transverse mounted shock absorber, called a yaw damper, helps keep railcars from swaying excessively from side to side and are important in commuter railroads and rapid transit systems because they prevent railcars from damage station platforms. In a vehicle, it reduces the effect of traveling over rough ground, leading to improved ride quality, and increase comfort due to substantially reduced amplitude of disturbances.[5]

II. METHOD & MATERIAL

Method

Solid Modelling:-

1. Design of Top Rod

   Making the first part of the design lets take top plane and draw the circle with required dimension then exit from the sketch andextrude it. Again select the top plane then draw the circle with 10mm diameter and then extrudeit up to 70 mm. Now select the back face and draw a circle with diameter 24mm and extrude it 28mm.select the edge and apply fillet with 6mm radius. Cutting the sections by leaving the 15 mm gap. Take the cutting surface and draw circlewith 8 and 18mm diameter and extrude by applying convert entities. The part is completed.

2. Design of Piston Rod:-

   The designing procedure of piston rod using solidworks design tool. Select a top plane, draw a circle with 24mm diameter and extrude it 108.93mm. Select a edge and fillet it to 3mm.Again cut the section as like in the first part. Take the another edge and draw a circle with 27mm diameter and extrude it up to 80.93mm.Again select the down surface and draw a circle then do a extruded cut up to 70mm length. Do the threading up to 50mm using helix command

3. Design of spring

   The designing procedure of spring using solidworks design tool. Select a front plane and draw a line in downward direction and then give dimension. Again select a front plane draw a circle with diameter 7.25mm

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and put 15mm distance from the line. Exit from the sketch go to feature and select swept boss. Then the required spring will be obtained.

4. Design of screw:-
The designing procedure of screw using solidworks design tool. Select top plane sketch a circles with 52mm outer diameter and 24mm inner diameter. Extrude it with9mm.Draw a circle with 29mm diameter and again extrude it with 1mm.Select top face ,draw center lines and draw a circle with 2 mm radius. Draw the lines from circle to outer circle the angle between the lines is 60 degrees and then trim the circle. Now apply the polar array then apply extrude cut. Then the required screw is obtained.

5. Assembling of PSD shock absorber using solid works
Select top plane sketch a circles with 52mm outer diameter and 24mm inner diameter. Extrude it with9mm.Draw a circle with 29mm diameter and again extrude it with 1mm.Select top face ,draw center lines and draw a circle with 2 mm radius. Draw the lines from circle to outer circle the angle between the lines is 60 degrees and then trim the circle. Now apply the polar array then apply extrude cut. Then the required screw is obtained

Finite Element Analysis

1. Importing the Model
The assembled model was imported. The contacts between the surfaces are automatically detected in Ansys.

2 Assigning Materials
The material properties of the spring, upper and lower mounts were defined. Stainless Steel was selected as the material of choice for the lower and upper mounts, and a variety of materials were chosen one at a time for the spring. The essential material properties defined were the modulus of elasticity, density and Poisson‟s ratio.

Raw Material

Spring Steel:-
Spring steels are generally low-alloy manganese, medium-carbon steel or high-carbon steel with a very high yield strength. This allows objects made of spring steel to return to their original shape despite significant deflection or twisting. Material Properties of spring steel as follow.

Young's Modulus :- 202000 (N/mm^2)
Density:-7820 (Kg/mm^3)
Poisson's Ratio:- 0.292

Copper Alloy:-
The copper is high strength with non-magnetic and non-sparking qualities. It has excellent metalworking, forming and machining properties.

Young's Modulus :- 130000 (N/mm^2)
Density:-8100 (Kg/mm^3)
Poisson's Ratio:- 0.285

Titanium Alloy
Titanium alloys are metals that contain a mixture of titanium and other chemical elements. Such alloys have very high tensile strength and toughness (even at extreme temperatures). They are light in weight, have extraordinary corrosion resistance and the ability to withstand extreme temperatures. However, the high cost of both raw materials.
Young's Modulus :- 102000 (N/mm^2)

Density:-4850 (Kg/mm^3)
Poisson's Ratio:- 0.3

Table.1: Types of material

Material	Elastic modulus	Poisson's Ratio	Mass density
Stainless steel	290075470.53psi	0.28	1167905.8psi
Titanium alloy Ti-6Al-25n-2Zr-2Mo-2Cr-0.25Si(SS)	17839641.88psi	0.33	168243.78psi
Berrylium Copper UNS,C17000	16679339.83psi	0.3	7251886.88psi

III. RESULT & DISCUSSION

Design Calculations for Helical springs for Shock absorbers
Material: Steel(modulus of rigidity) G = 41000
Mean diameter of a coil D=62mm
Diameter of wire d = 8mm
Total no of coils n1= 18
Height h = 220mm
Outer diameter of spring coil D0 = D +d =70mm
No of active turns n= 14
Weight of bike = 125kgs
Let weight of 1 person = 75Kgs
Weight of 2 persons = 75×2=150Kgs
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
We Know that, compression of spring (δ) = C = spring index = 7.75 = 8 (δ) = × × × /× = 282.698 Solid length, Ls=n1×d=18×8=144
Free length of spring, Lf = solid length + maximum compression + clearance between adjustable coils = 0.15 = 144 + 282.698 + 0.15 × 282.698 = 469.102
Spring rate, K = 5.719
Pitch of coil P = 26
Stresses in helical springs: maximum shear stress induced in the wire τ = 0.97
Values of buckling factor KB= 7.5 K = 0.05 (for hinged and spring)
The buckling factor for the hinged end and built-in end spring Wcr=5.719×0.05×469.102=134.139N

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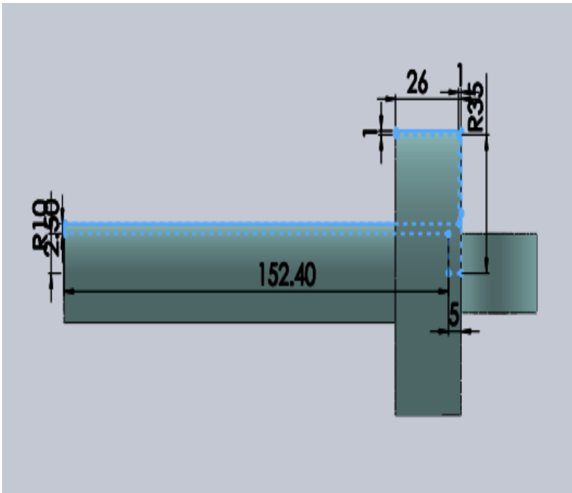
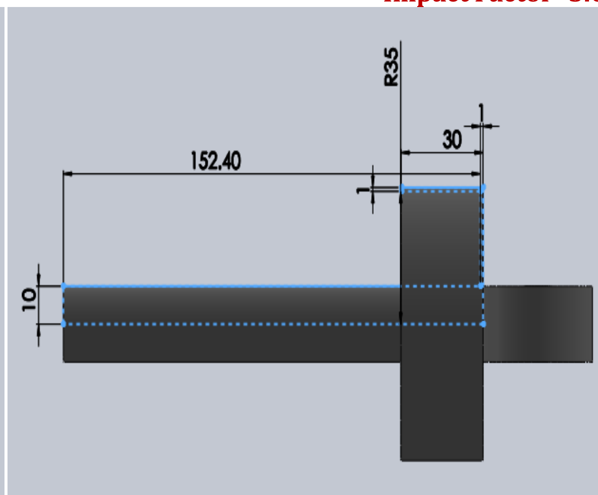
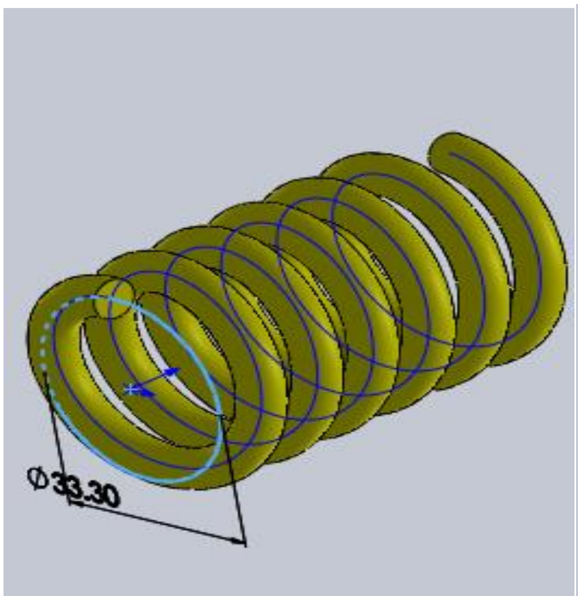


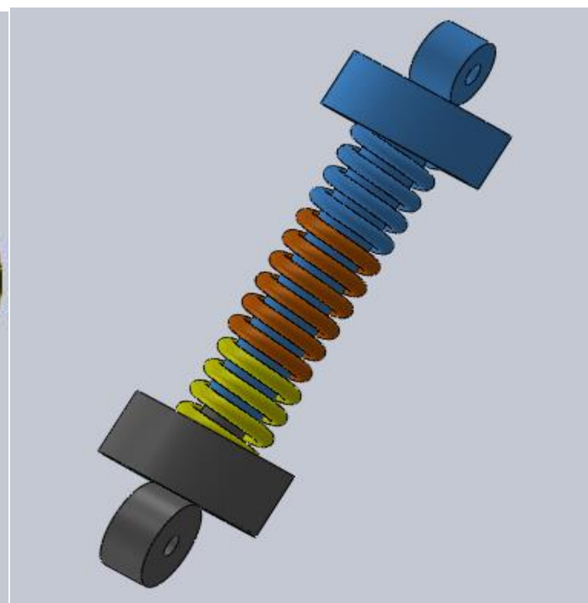
Top rod



Bottom rod



Spring


Assembly

Obtaining results after applying loads.
CST (Copper Steel Titanium)

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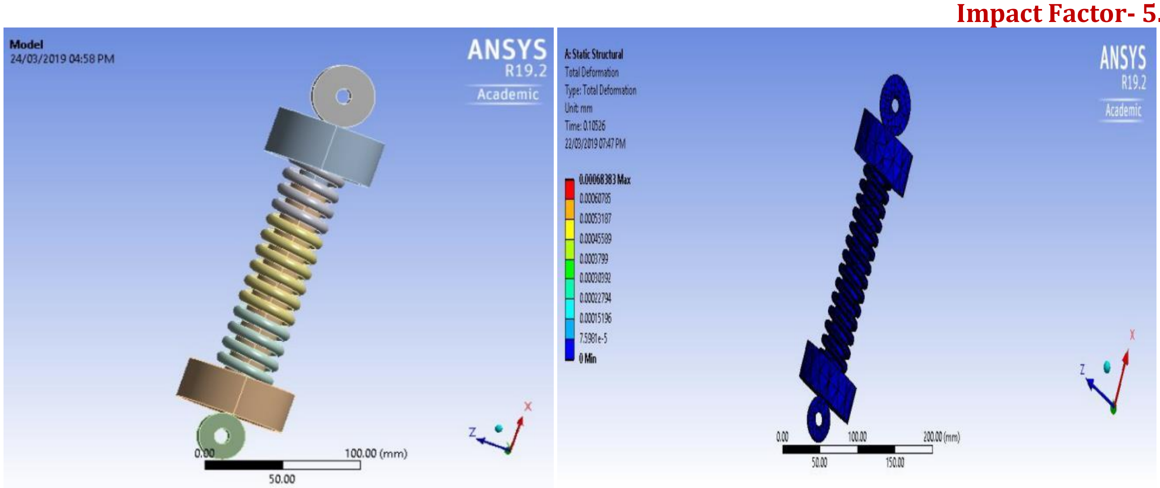
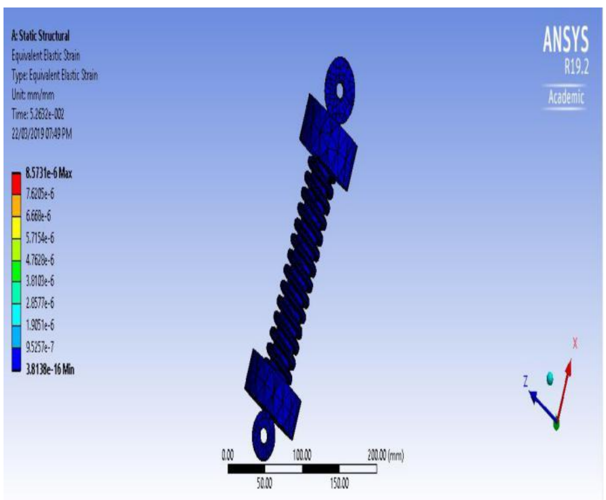
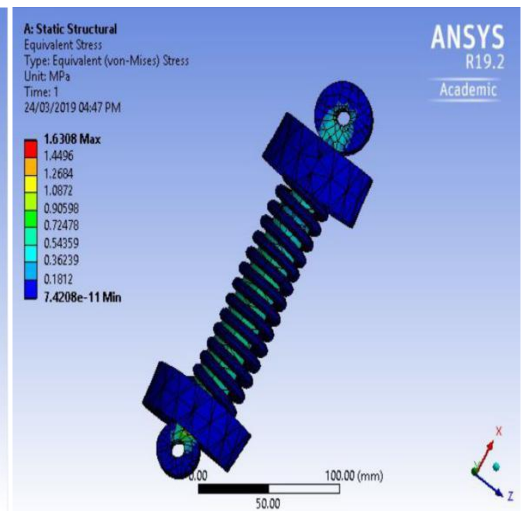


CST Total deformation



CST Equivalent Elastic Strain



CST Equivalent Stress

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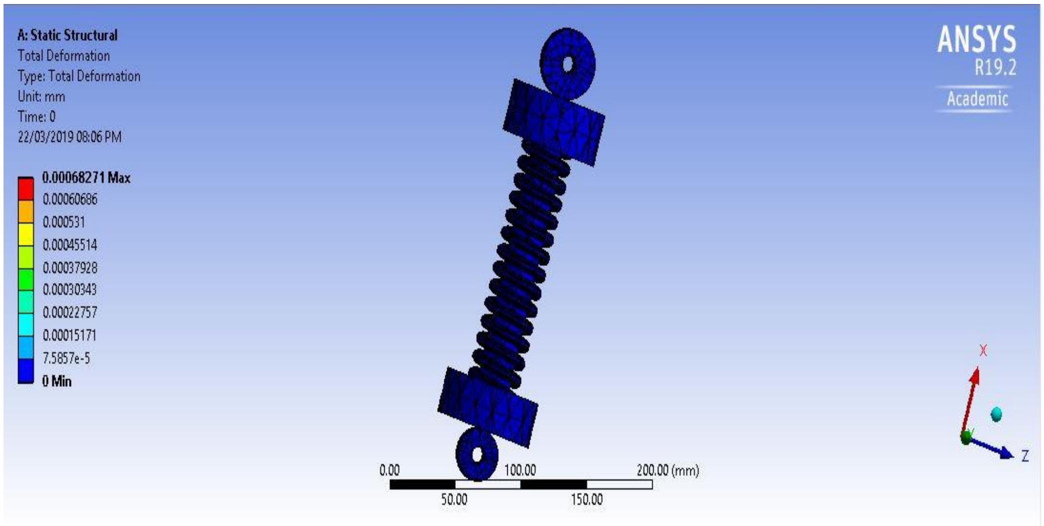
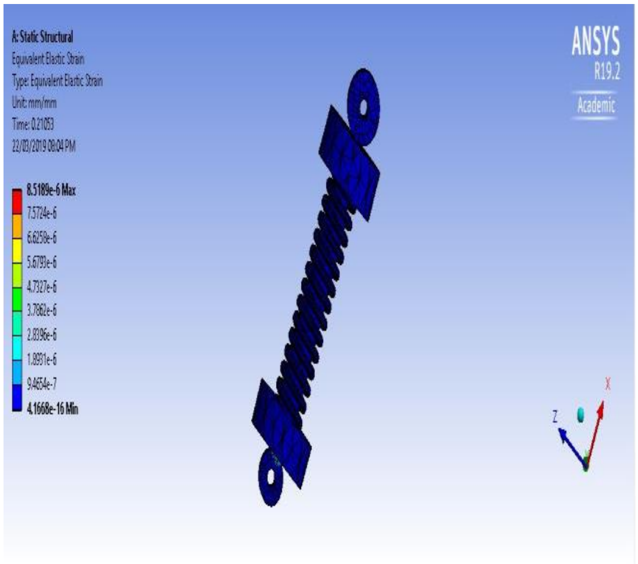
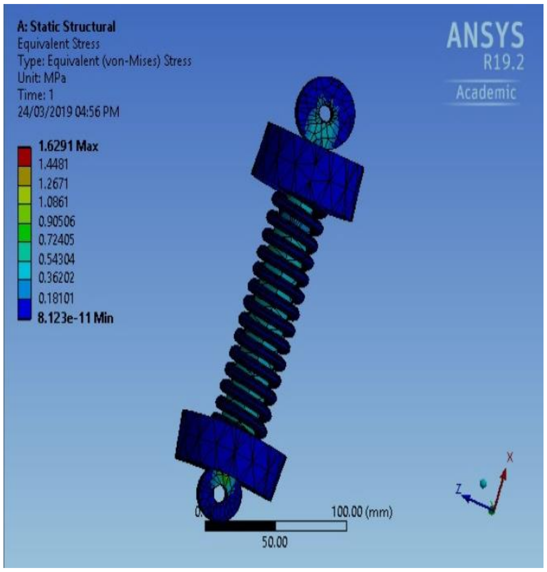
CTS (Copper Titanium Steel)



CTS Total deformation

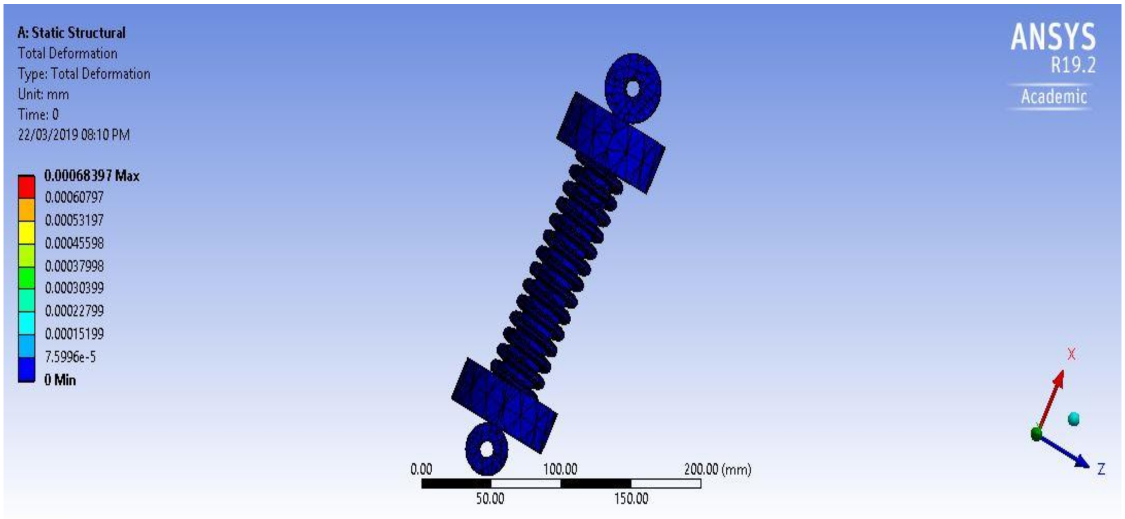




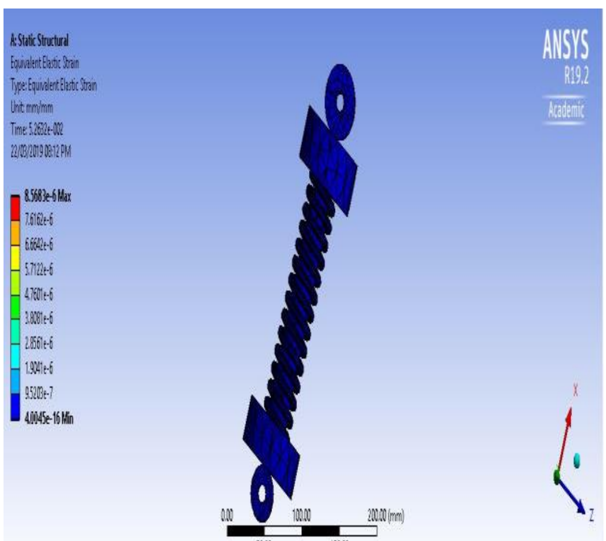
CTS Equivalent Elastic Strain

CTS Equivalent Stress

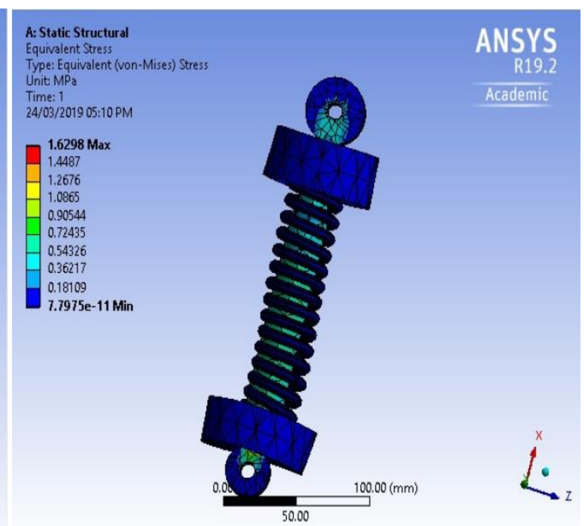
SCT (Steel Copper Titanium)



SCT Total deformation

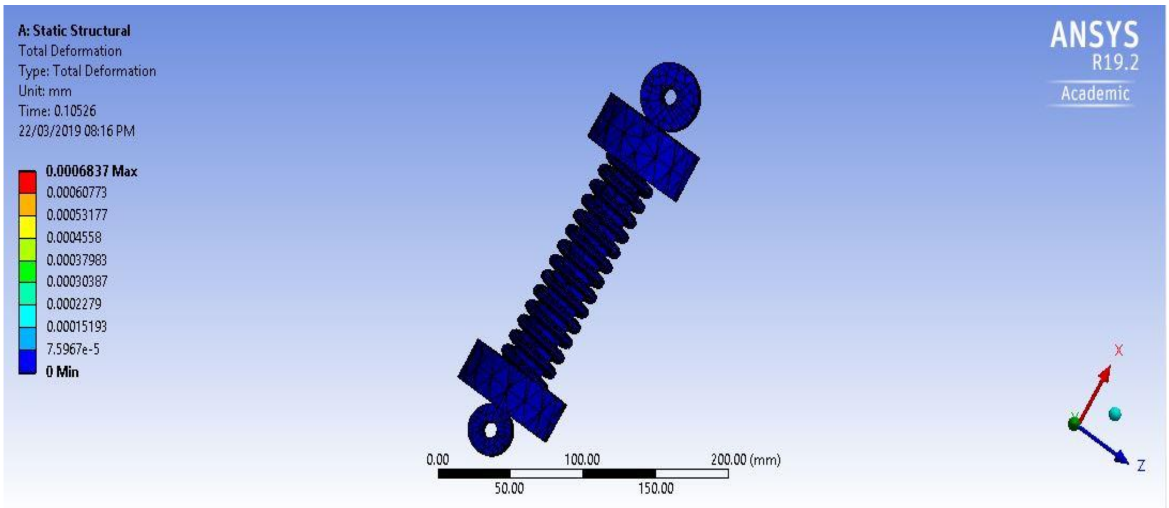


SCT Equivalent Elastic Strain

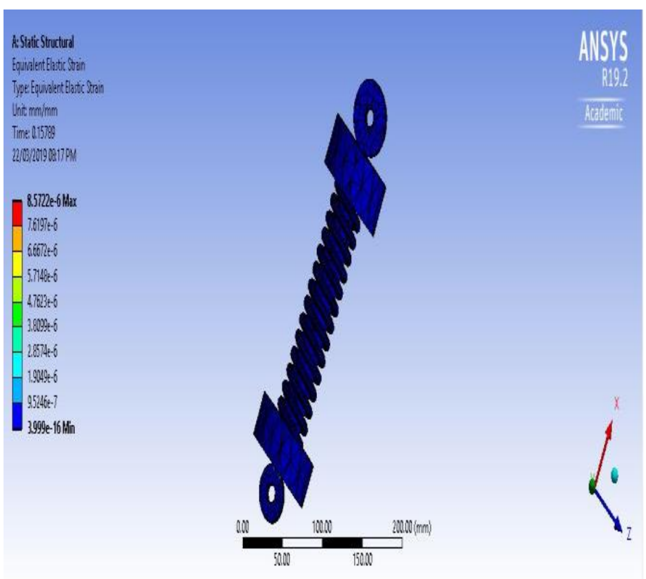


SCT Equivalent Stress

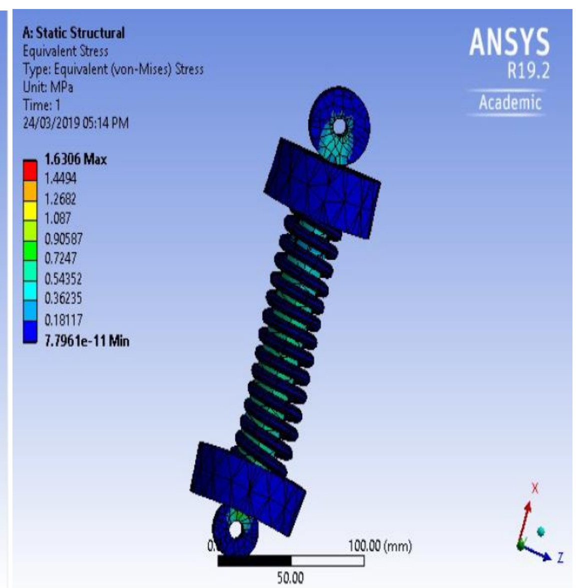
STC (Steel Titanium Copper)



STC Total deformation



STC Equivalent Elastic Strain



STC Equivalent Stress

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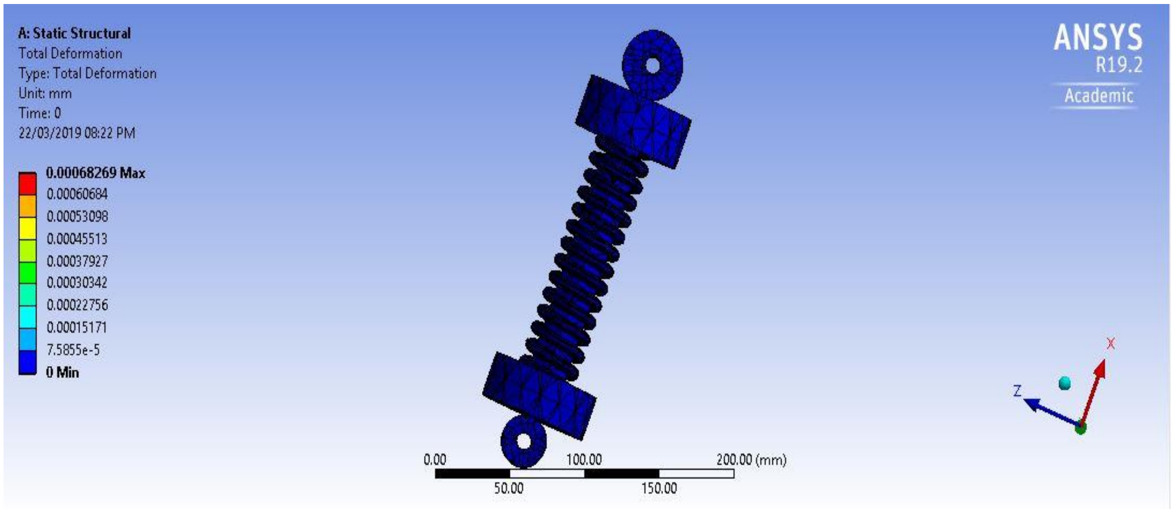
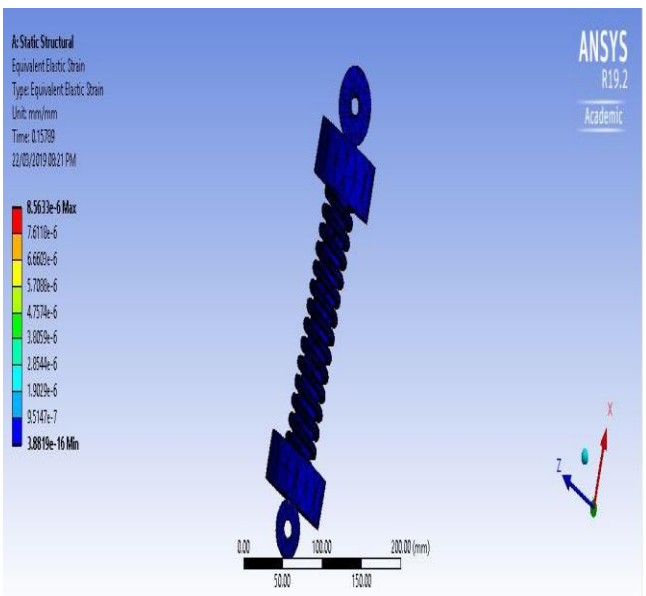
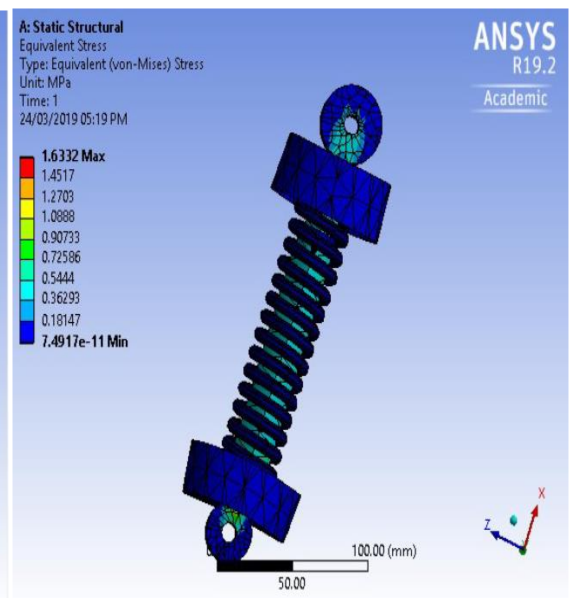
TCS (Titanium Copper Steel)



TCS Total deformation



TCS Equivalent Elastic Strain



TCS Equivalent Stress

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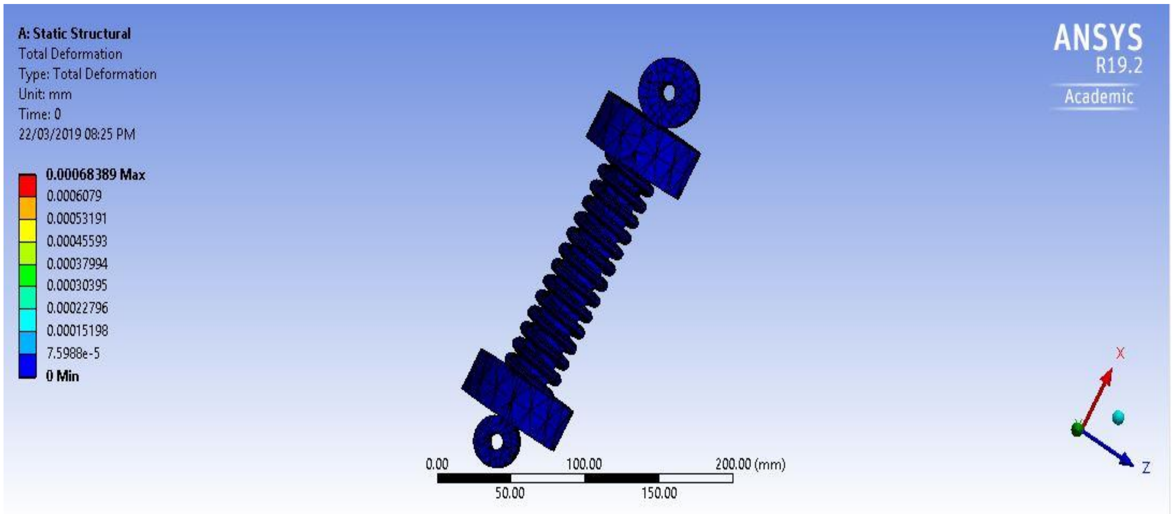
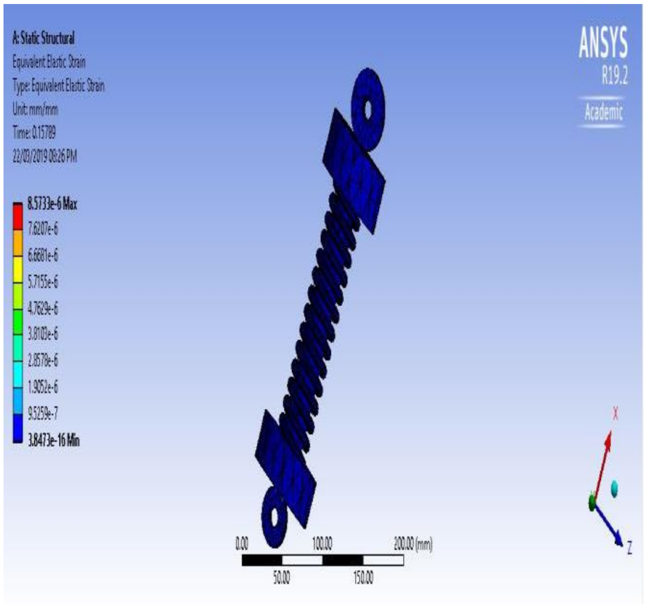
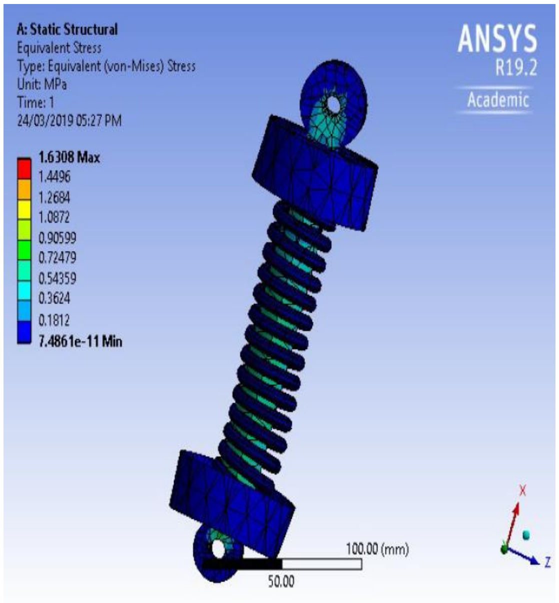
TSC (Steel Titanium Copper)



TSC Total deformation





TSC Equivalent Elastic Strain *TCS Equivalent Stress*

Stress and Deflections with different materials as Shock Absorber Spring:

Table.2: Types of Stress and Deflections

Materials	Von-mises stresses (Mpa)		Deformation (mm)
	Max	Min	Max
CST (Copper Steel Titanium)	**1.6308**	**7.4208e**	**0.00068383**
CTS (Copper Titanium Steel)	**1.6291**	**8.123e**	**0.00068271**
SCT (Steel Copper Titanium)	**1.6298**	**7.7975e**	**0.00068397**
STC (Steel Titanium Copper)	**1.6306**	**7.7961e**	**0.0006837**
TCS (Titanium Copper Steel)	**1.6332**	**7.4917e**	**0.00068269**
TSC (Steel Titanium Copper)	**136208**	**7.4861e**	**0.00068389**

IV. CONCLUSION

As of now, we have compared the properties, availability and cost of various materials of spring. Based on these parameters, we have selected steel spring (ASTM A228), Phosphor Bronze, Titanium Alloy as an optimum alternative to spring shock absorber.

V. FUTURE SCOPE OF THE STUDY

After the successful validation of this spring we can use this spring where more loads are to be used especially in modern bikes also we can implement this in industrial shock absorbers

VI. ACKNOWLEDGEMENTS

The success of our project was not due to our project work alone, but also due to interest help and able guidance offered to us by the staff members of Mechanical Engineering Department.

It is our duty to acknowledge with gratitude the help rendered to us by these individuals, without whom we would not been able to carry out project to best of our ability and to the satisfaction of our superior.

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