ISSN No:-2456-2165

Design and Analysis of Shock Absorber

Manga Hymanjali[1]
Assistant Professor Dept. of Mechanical Engineering,
Warangal Institute of Technology and Science,
Warangal.

Elumagandla Surendar[2]
Hod& Associate Professor, Dept. of Mechanical Engineering, Warangal Institute of Technology and Science,
Warangal.

Nalla Suresh[3]
Assistant Professor Dept. of Mechanical Engineering
Warangal Institute of Technology and Science, Warangal.

Abstract:- 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. In present work a 3D model of shock absorber is designed using CATIA V5 R20. The model is tested with different materials for absorber and also for spring. Structural analysis and modal analysis are done on the shock absorber by varying different spring materials. Spring materials are Spring Steel, Chrome vanadium, Beryllium Copper and Inconel X750. The analysis is done by considering all loads acting such as persons weight, bike weight etc. single Modal analysis is done for different frequencies to understand deformations at 10 different number of modes. The variation of von-misses stress, von-misses strain and deformation has been done using ANSYS.

***Keywords**:- Spring, Shock Absorber, Automotive, CAD, FEA, Static, modal analysis CATIA V5 R20, ANSYS.*

I. INTRODUCTION

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.

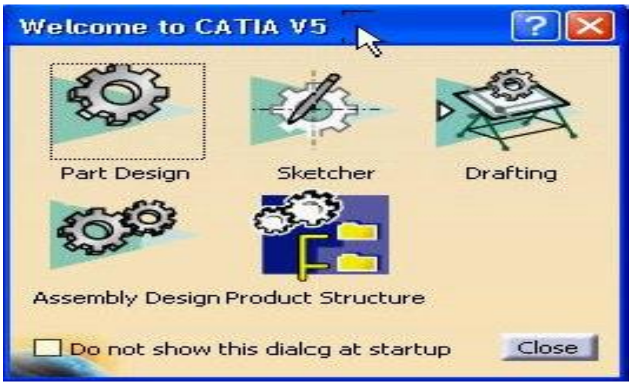
The design of shock absorber in suspension system is very important.

Approaches To design Shock Absorbers: following are some commonly-used approaches to shock absorption:

- Dry friction
- Structural
- Composite
- Conventional
- Thermal
- Magnetic
- Fluid or compressed gas

Software's Used : In this project I will be using the two basic design software's, they are AutoCAD, CATIA , for designing.

CATIA - abbreviation is Computer Aided Three-dimensional Interactive Application. Version 5 and revision 20 is used for designing of shock absorber which consists of the following modules.



Introduction to Ansy.

ANSYS is the standard FEA tool within the Mechanical Engineering Department and also used in Civil and Electrical Engineering. ANSYS provides a cost-effective way to explore the performance of products or processes in a virtual environment. This type of product development is termed virtual prototyping. With virtual prototyping techniques, users can iterate various scenarios to optimize the product long before the manufacturing is started. This enables a reduction in the level of risk, and in the cost of ineffective designs.

Steps in Finite Element Analysis:

- Descritization

- Formulation of properties to each element and concern nodes.
- Assemble all elements for structure
- Give input such as load , forces ,temperatures etc based on type of analysis means structural, thermal etc.
- Solve simultaneous line algebraic equations
- Display the results in the form of graphs.

The finite element method is a numerical analysis technique for obtaining approximate solutions to a wide range of engineering problems.

II. LITERATURE REVIEW

A. Chinnamahammad bhasha, N. Vijay rami reddy, B. Rajnaveen [1], worked on suspension system also designed and a 3D model is created using CATIA V5 R21. They used spring steel, phosphor bronze, berilium copper and titanium alloy as spring material. They considered weight of bike with double riding. Finally comparison is done for different materials to verify best material for spring in Shock absorber. Modeling is done in CATIA and analysis is done in ANSYS.

Mr. Sudarshan Martande1, Mr. Y. N. Jangale etc all [2], focused on new correlated methodologies that will allow engineers to design components of Shock Absorbers. Thus this paper focuses on to develop new correlated methodologies that will allow engineers to design components of Shock Absorbers by using FEM based tools. Syambabu Nutalapati [3], . In this project a shock absorber is designed and a 3D model is created using CATIA. Structural and modal analysis are done on the shock absorber by varying material for Spring Steel and Molybdenum. Pinjarla Poornamohan, Lakshmana Kishore [4], In their project a shock absorber is designed and a 3D model is created using Pro/Engineer. Thickness of spring is also varied and the material is spring steel and beryllium copper. Structural analysis is done to verify the displacement at number of nodes at different frequencies using Ansys. Rahul Tekade, Chinmay Patil [5], has carried Structural and Modal Analysis of Shock Absorber of Vehicle to sustain more vibrations at all conditions. Johnson*, Davis Jose, Anthony Tony[6], were designed and analysed a shock absorber manufactured with different materials which is working under different load and road conditions. Vijay Barethiye, G. Pohit, A. Mitra [7], an experiment was conducted to obtain dynamic characteristics of a shock absorber. The results were compared both linear and hysteresis behavior more accurately. W.Shivaraj Singh, N.Srilatha [8], were reviewed all the literature available on analysis of shock absorber working under different loads.

Xiao-HongLong[ab], Yong-TaoMa[a] etc all[9], were analysed two different absorbers with two different materials under shock loads. Most damaging areas also identified for both set of absorbers of bridge structure. MarouaneBenaziz, SamuelNacivet etc.al [10], were conducted experimentation to identify noise behavior and sensitivity of a shock absorber Dheeman Bhuyan, Kaushik Kumar[11], were used PTC CREO 2.0 for designing of a twin tube shock absorber and using ANSYS Workbench 15.0 the results were shown at different velocities of the fluid in absorber. Tongyi Xu, Ottawa, Canada[12], In this study, a TTM-based vibration absorber with variable moment of inertia (TTM-VMI) is proposed. Dheeman Bhuyan, Kaushik Kumar [13], CFD Analysis has been done on piston valve in the suspension system and design was created by using CREO 2. PiotrCzop, Damian S Ławik [14], Used A Special Servo- Hydraulic Tester To Evaluate The Vibration Levels With In A Shock Absorber.

III. DESIGNING & ANALYSIS

We have been supplied with the .igs file of the Shock Absorber; I have designed the Shock Absorber according to the dimensions supplied to me in CATIA V5. The following figure shows the development of the design in the CATIA V5.

Isometric view of SHOCK ABSORBER

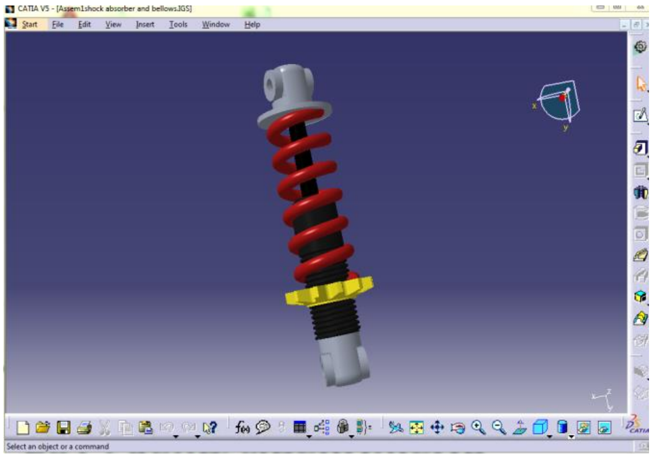


Fig 3.1. Model in CATIA V5

The model is designed with the help of CATIA and then import on ANSYS for Meshing and analysis. The analysis by Static Structural is used in order to calculating deformation and stresses in it. For meshing, the geometry is opened in Mechanical model, then all thickness edges are meshed.

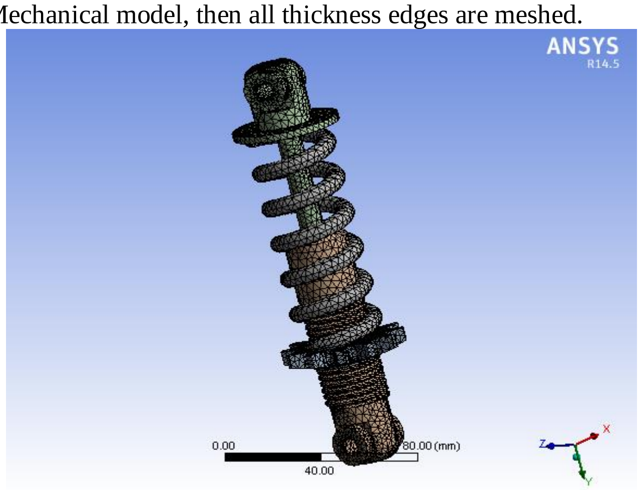


Fig 3.2: Meshed model in ANSYS

Materials Used: In this project, I have been used different materials for shock absorber components and springs. The used material data shown in below.

Shock Absorber Component Materials:

ISSN No:-2456-2165

S.No	Material name	Density Kg/mm³	Young's modulus (E) Mpa	Poisson's ratio (µ)
1	Aluminum Alloy	2.77e-8	71000	0.33
2	Carbon Steel	7.87e-6	2e+5	0.29
3	Stainless Steel	7.775e-6	1.93e+5	0.31

Table 3.1: Shock Absorber Materials and its Properties

S.No	Spring Material	Density Kg/mm³	Young's modulus (E) Mpa	Poisson's ratio (µ)
1	Beryllium Copper (B197)	8.2486e-6	1.277e+5	0.27
2	Chromium Vanadium (A232)	7.861e-6	2.0684e+5	0.27
3	Inconel750 (B673)	8.2486e-6	2.1374e+5	0.27
4	Spring Steel	7.8e-6	1.9e+5	0.29

Table 3.2: Spring Materials and its Properties

Shock Absorber spring Materials:

Static, Structural Analysis for Shock Absorber:

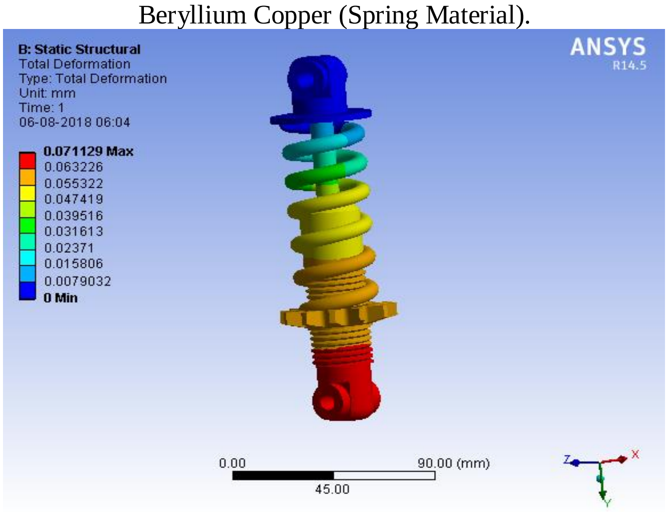
In this work, I selected Aluminum Alloy, Carbon Steel and Stainless Steel materials for shock absorber components other than spring and for the spring material for Static structural analysis Beryllium copper, Chromium Vanadium, Inconel 750 and Spring Steel.

Variations of different parameters such as Total deformation, Von-misses Strain and Von-misses Stresses has been observed with different materials combination as mentioned above at standard design load condition i.e 5000N.

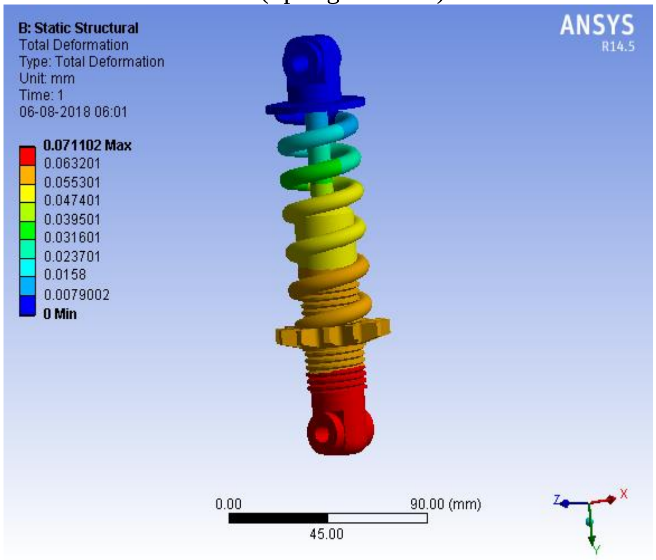
3.3: Analysis By Applying Aluminum For Absorber Material & Different Spring Materials :

3.3.1: Observation on total Deformation

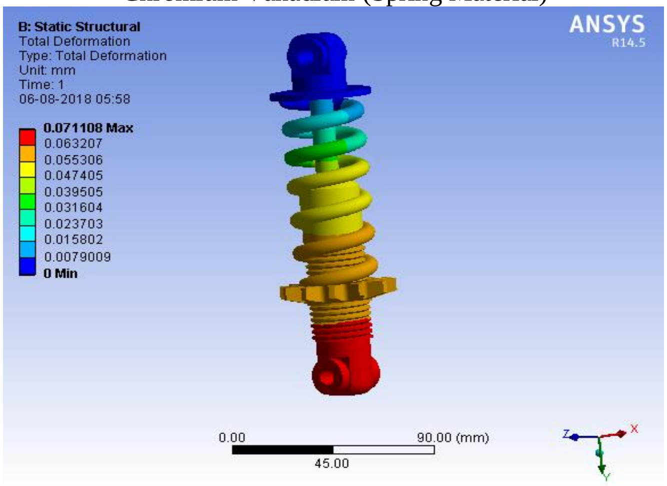
Case 1: When the Aluminum (Absorber Material) & Beryllium Copper (Spring Material).



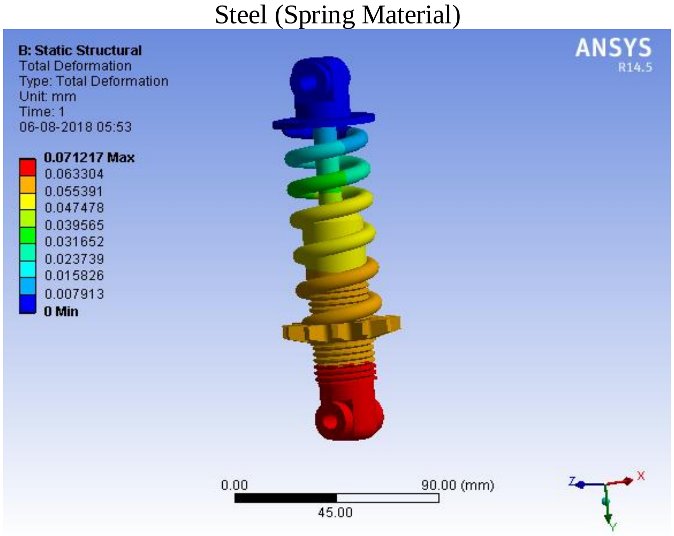
Case 2: When the Aluminum (Absorber Material) & Inconel 750 (Spring Material)



Case 3: When the Aluminum (Absorber Material) & Chromium Vanadium (Spring Material)

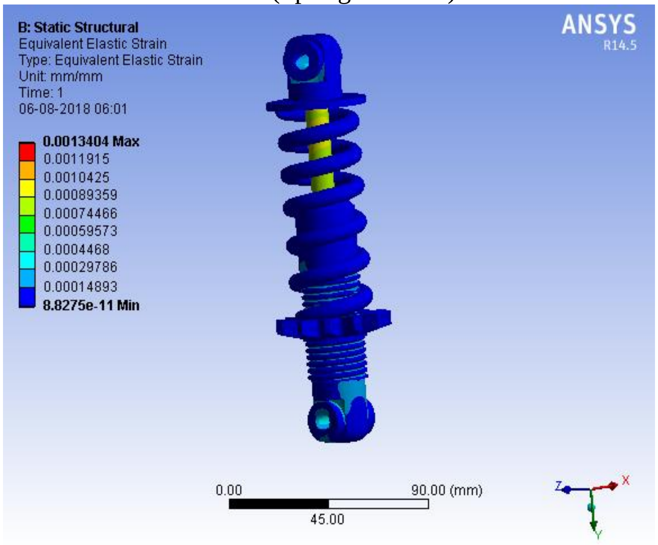


Case 4: When the Aluminum (Absorber Material) & Spring Steel (Spring Material)

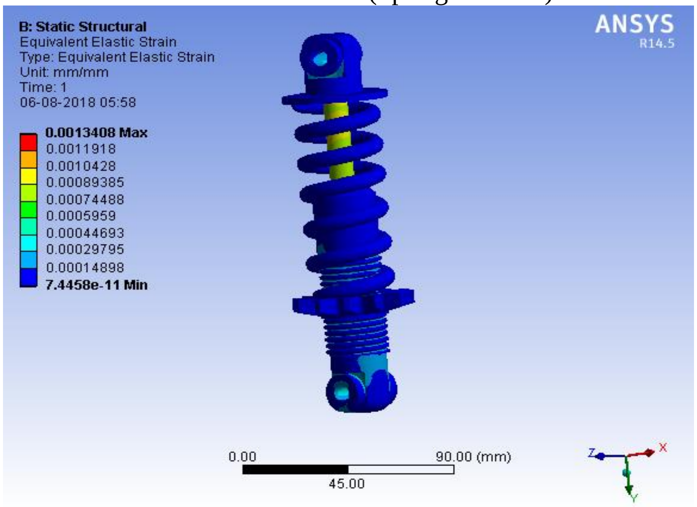


3.3.2: Observations on Von-Misses Strain

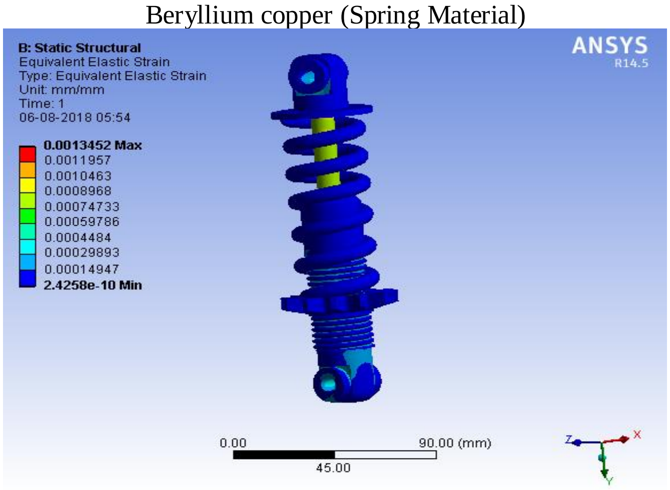
Case 1: When the Aluminum (Absorber Material) & Inconel 750 (Spring Material)



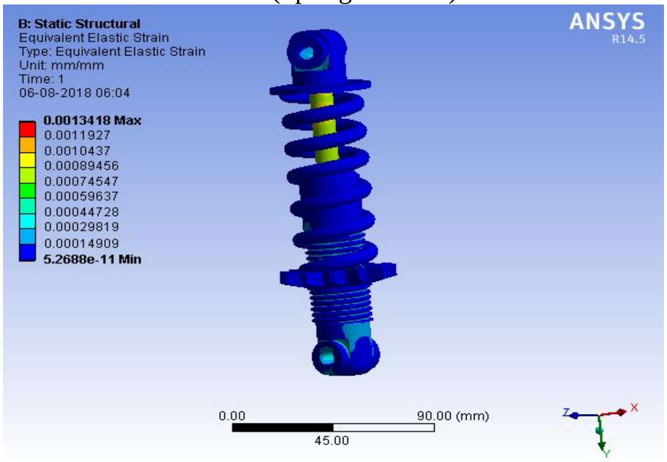
Case 2: When the Aluminum (Absorber Material) & Chromium Vanadium (Spring Material)



Case 3: When the Aluminum (Absorber Material) & Beryllium copper (Spring Material)

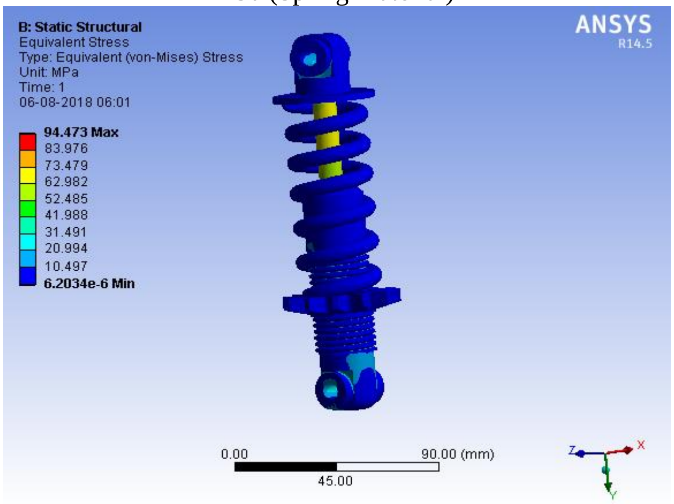


Case 4: When the Aluminum (Absorber Material) & Spring Steel (Spring Material)

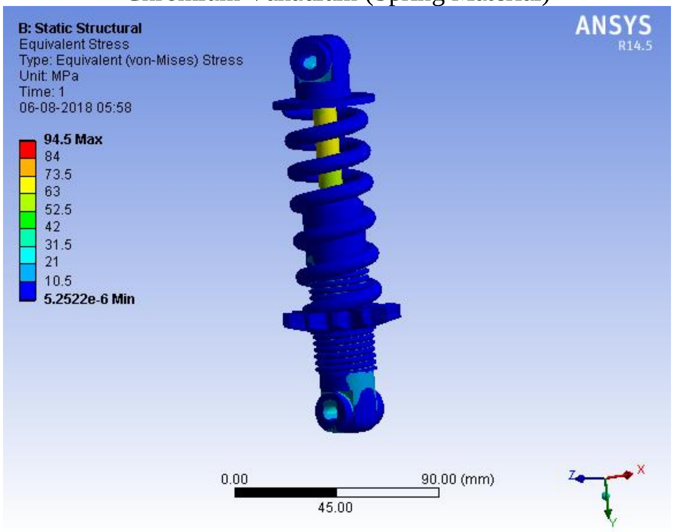


3.3.3: OBSERVATIONS ON VON-MISSES STRESSES

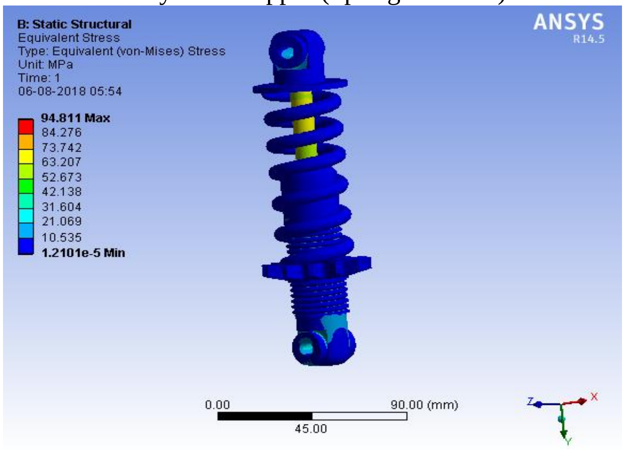
Case 1: When the Aluminum (Absorber Material) & Inconel 750 (Spring Material)



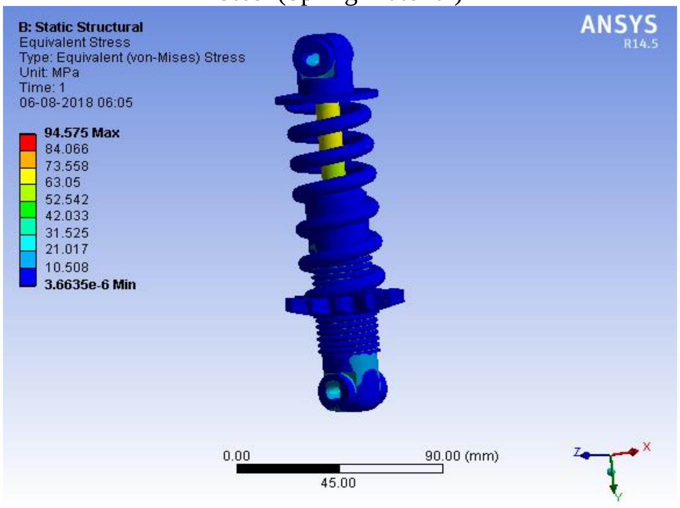
Case 2: When the Aluminum (Absorber Material) & Chromium Vanadium (Spring Material)



Case 3: When the Aluminum (Absorber Material) & Beryllium Copper (Spring Material)



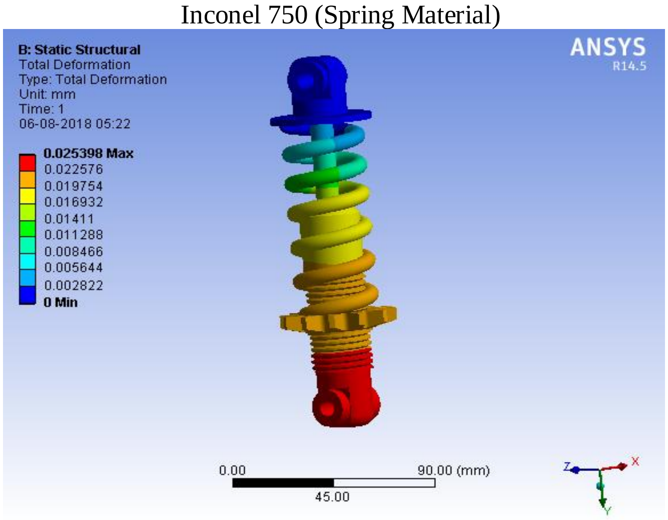
Case 4: When the Aluminum (Absorber Material) & Spring Steel (Spring Material)



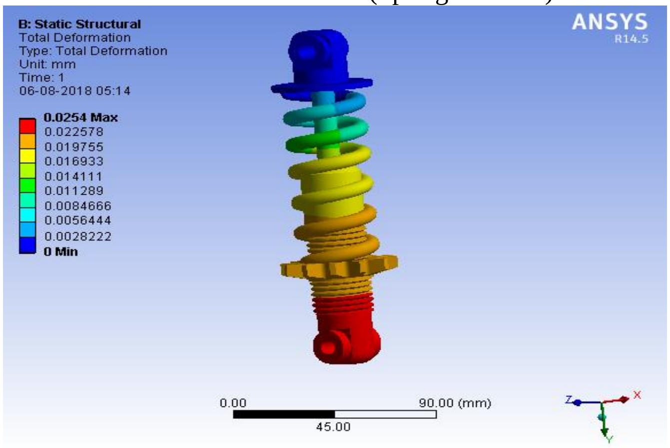
3.4 : ANALYSIS BY APPLYING CARBON STEEL FOR ABSORBER MATERIAL & DIFFERENT SPRING MATERIALS :

3.4.1:Observations on Total Deformation:

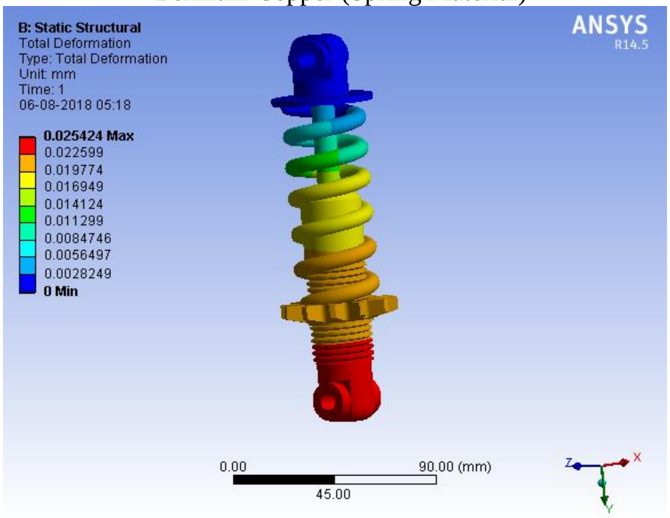
Case 1: When The Carbon Steel (Absorber Material) & Inconel 750 (Spring Material)



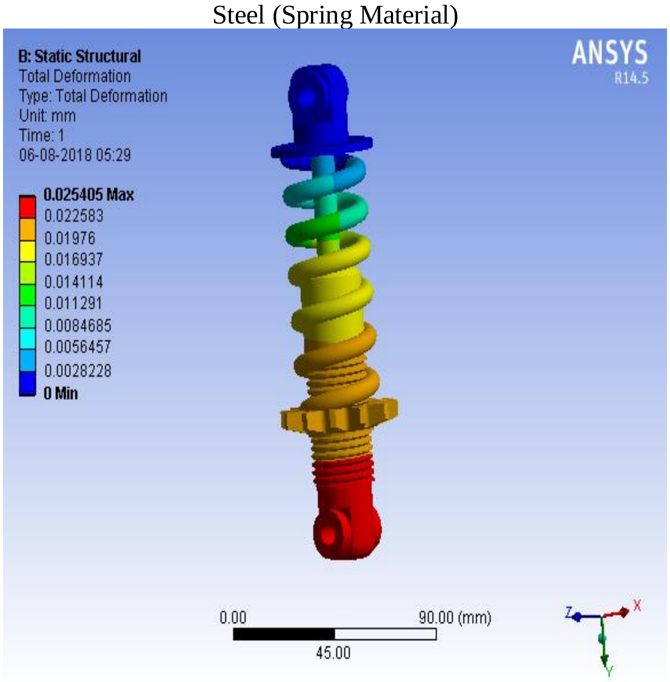
Case 2: When the Carbon Steel (Absorber Material) & Chromium Vanadium (Spring Material)



Case 3: When the Carbon Steel (Absorber Material) & Berilium Copper (Spring Material)



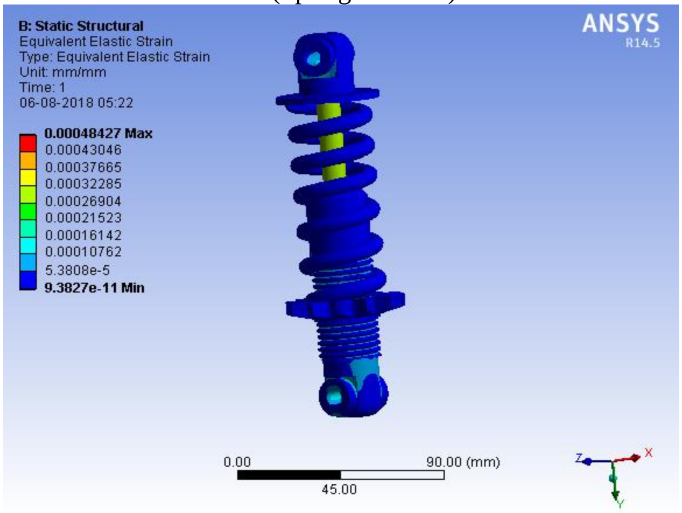
Case 4: When the Carbon Steel (Absorber Material) & Spring Steel (Spring Material)



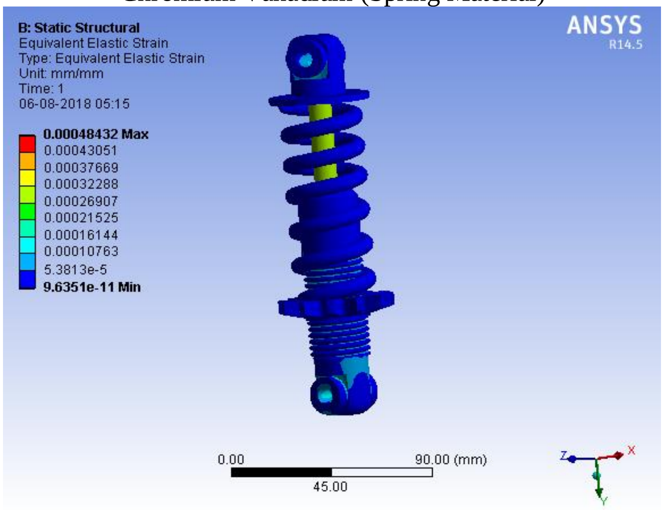
ISSN No:-2456-2165

3.4.2: OBSERVATIONS ON VON-MISSES STRAIN:

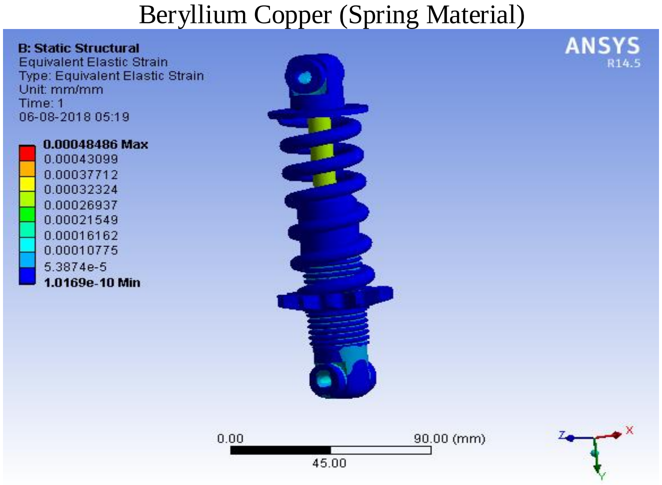
Case 1: When the Carbon Steel (Absorber Material) & Inconel 750 (Spring Material)



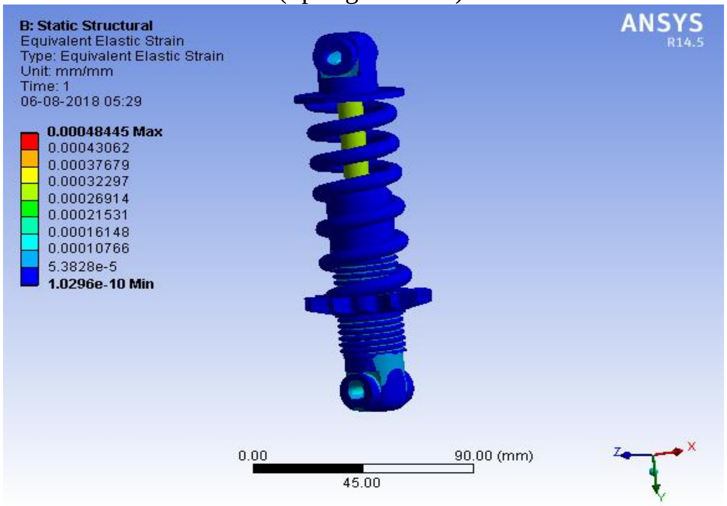
Case 2: When the Carbon Steel (Absorber Material) & Chromium Vanadium (Spring Material)



Case 3: When the Carbon Steel (Absorber Material) & Beryllium Copper (Spring Material)

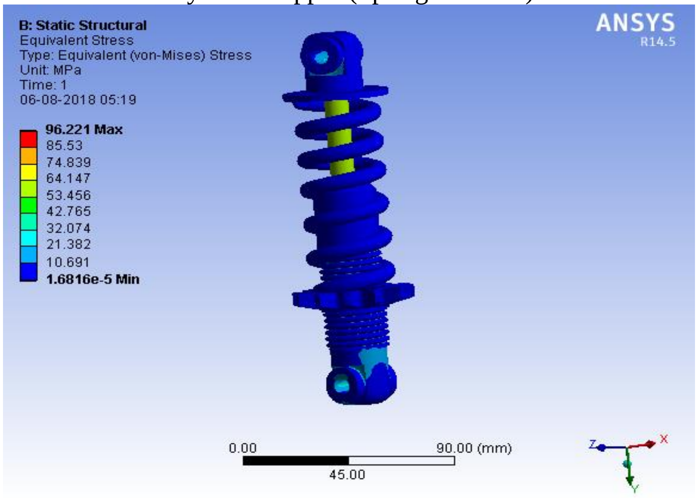


Case 4: When the Carbon Steel (Absorber Material) & Spring Steel (Spring Material)

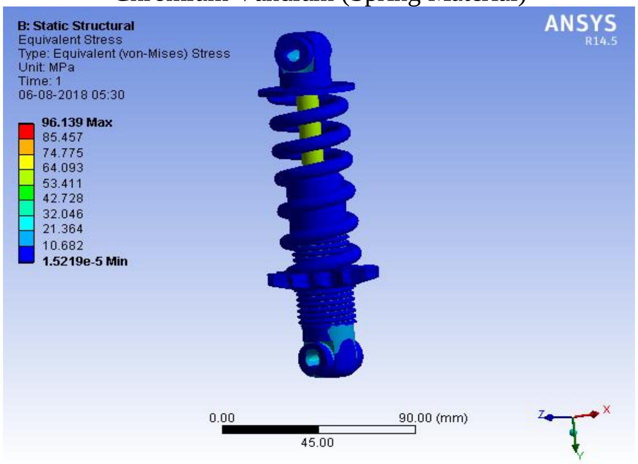


3.4.3: OBSERVATIONS ON VON-MISSES STRESSES:

Case 1: When the Carbon Steel (Absorber Material) & Beryllium Copper (Spring Material)

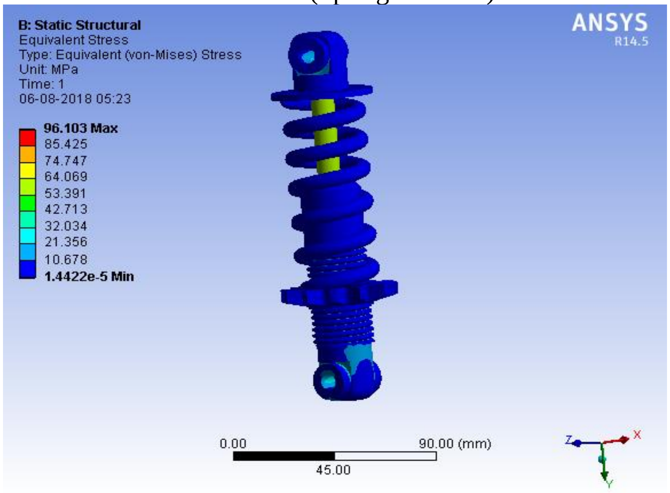


Case 2: When the Carbon Steel (Absorber Material) & Chromium Vandium (Spring Material)

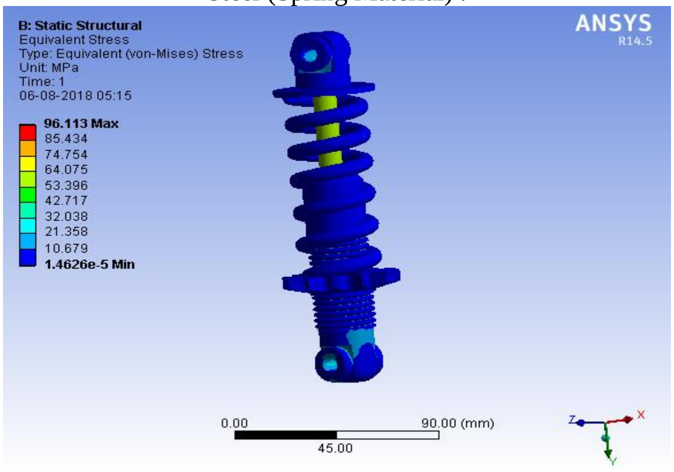


ISSN No:-2456-2165

Case 3: When the Carbon Steel (Absorber Material) & Inconel 750 (Spring Material)



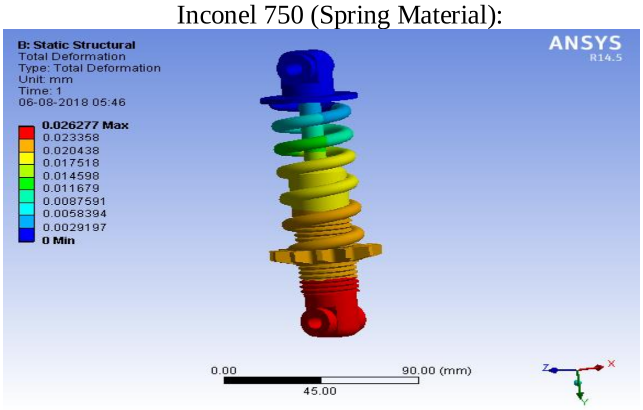
Case 4: When the Carbon Steel (Absorber Material) & Spring Steel (Spring Material) :



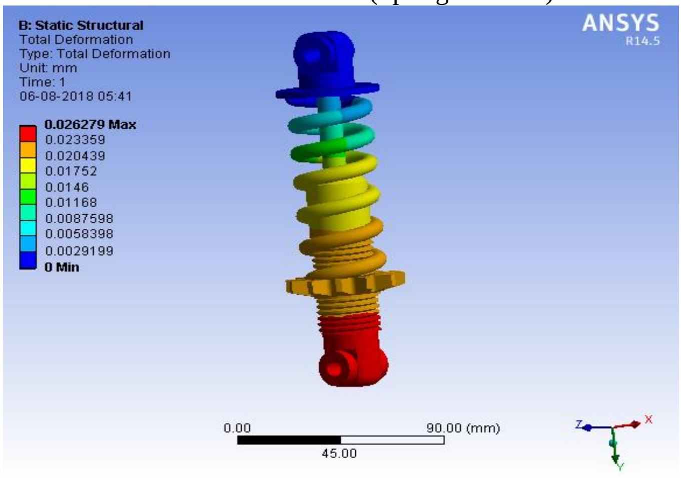
3.5: ANALYSIS BY APPLYING STAINLESS STEEL FOR ABSORBER MATERIAL & DIFFERENT SPRING MATERIALS:

3.5.1: OBSERVATIONS ON TOTAL DEFORMATION:

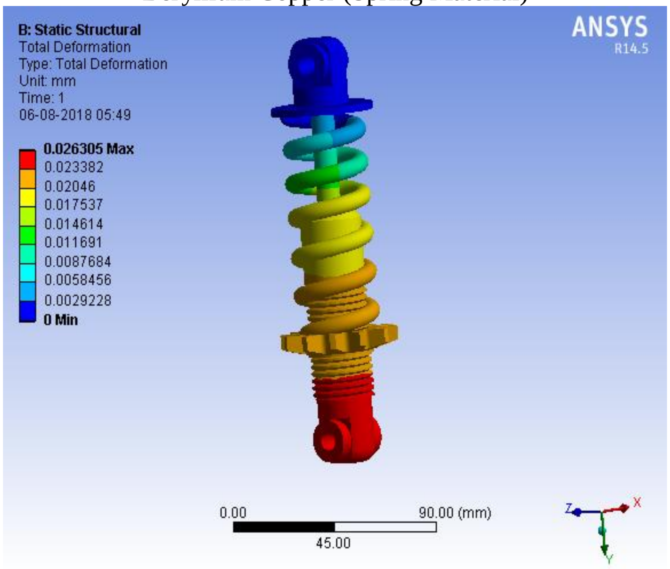
Case 1: When the Stainless Steel (Absorber Material) & Inconel 750 (Spring Material):



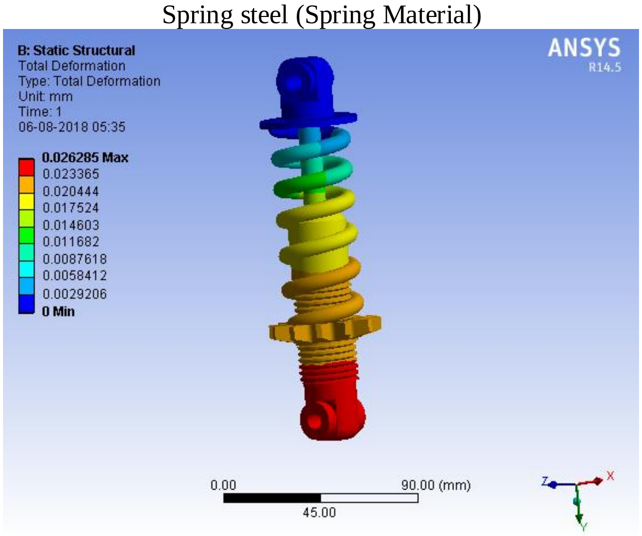
Case 2: When the Stainless Steel (Absorber Material) & Chromium Vanadium (Spring Material)



Case 3: When the Stainless Steel (Absorber Material) & Beryllium Copper (Spring Material)

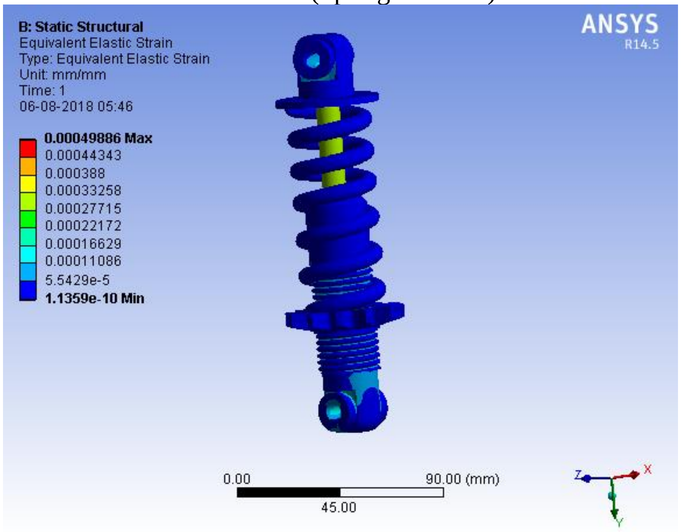


Case 4: When the Stainless Steel (Absorber Material) & Spring steel (Spring Material)

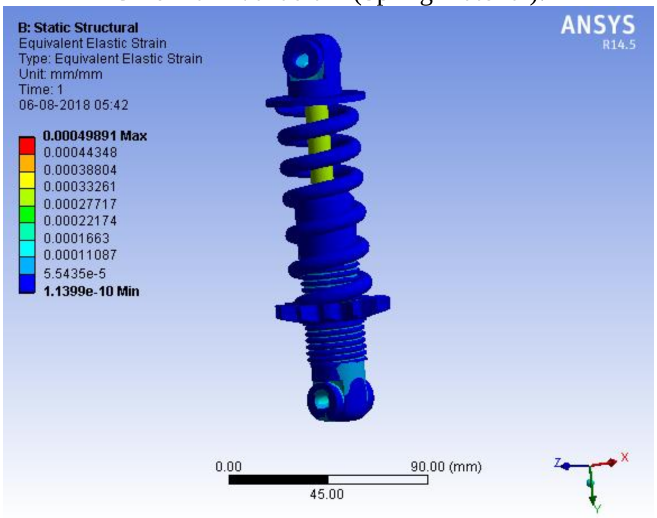


3.5.2 :OBSERVATIONS ON VON-MISSES STRAIN:

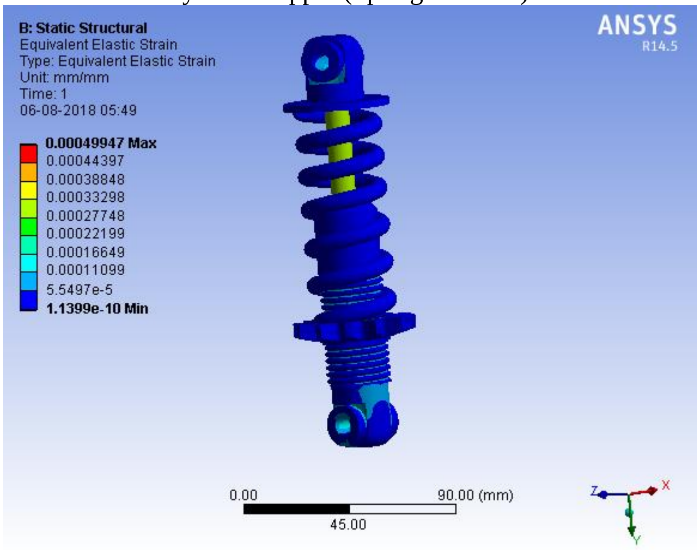
Case 1: When the Stainless Steel (Absorber Material) & Inconel 750 (Spring Material):



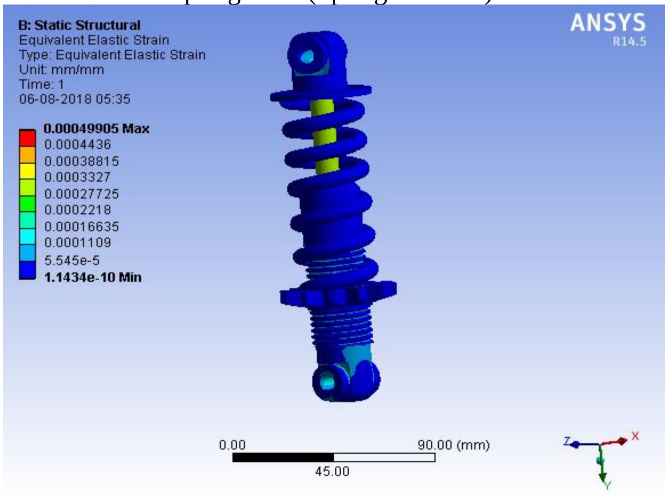
Case 2: When the Stainless Steel (Absorber Material) & Chromium Vanadium (Spring Material):



Case 3: When the Stainless Steel (Absorber Material) & Beryllium Copper (Spring Material):

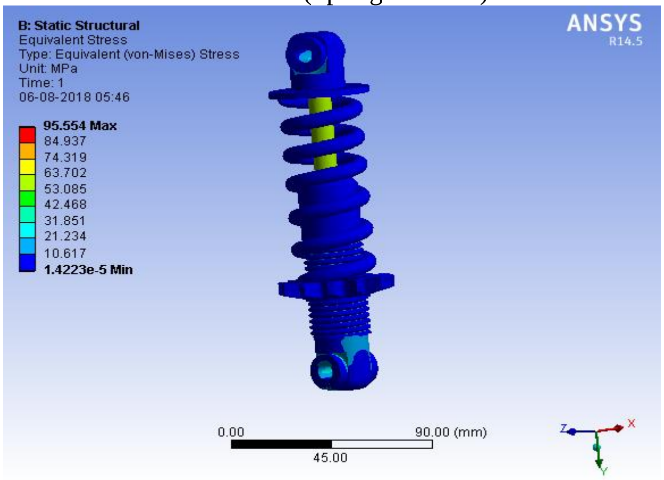


Case 4: When the Stainless Steel (Absorber Material) & Spring Steel (Spring Material):

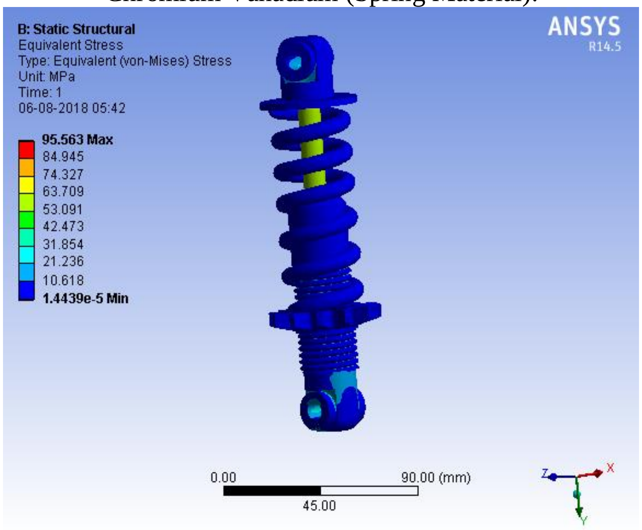


3.5.3 :OBSERVATIONS ON VON-MISSES STRESSES:

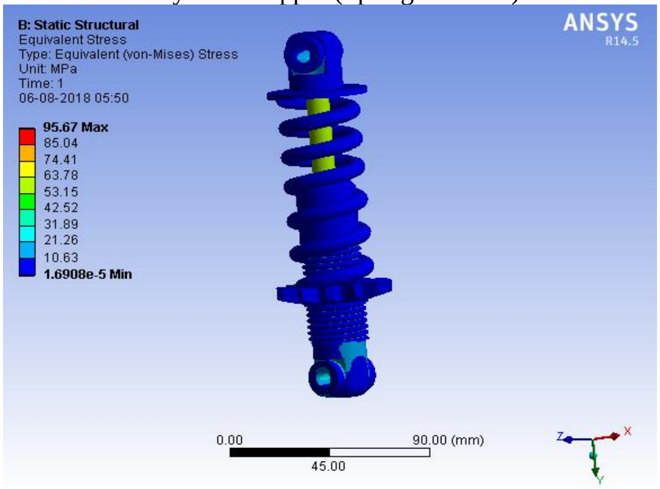
Case 1: When the Stainless Steel (Absorber Material) & Inconel 750 (Spring Material):



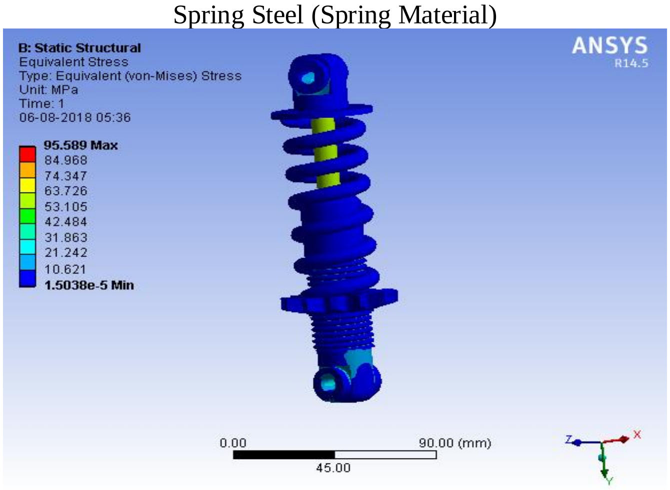
Case 2: When the Stainless Steel (Absorber Material) & Chromium Vanadium (Spring Material):



Case 3: When the Stainless Steel (Absorber Material) & Beryllium Copper (Spring Material):



Case 4: When the Stainless Steel (Absorber Material) & Spring Steel (Spring Material)



IV. RESULTS AND DISCUSSIONS

In this work, I selected Aluminum Alloy , Carbon Steel and Stainless Steel materials for shock absorber components other than spring and for the spring material for Static structural analysis Beryllium copper, Chromium Vanadium, Inconel 750 and Spring Steel.

Variations of different parameters such as Total deformation, Von-misses Strain and Von-misses Stresses has been observed with different materials combination as mentioned above at standard design load condition i.e 5000N.

The results were tabulated as follows.

Table 4.1: Variation of Total deformation in shock absorber by taking aluminum, carbon-steel and stainless steel as constant for absorber component material and Beryllium-copper, Chromium-Vanadium and Inconel 750 as spring material.

Al-Alloy	Beryllium-copper	0.071217
Al-Alloy	Chromium-Vanadium	0.071108
Al-Alloy	Inconel 750	0.071102
Al-Alloy	Spring Steel	0.071129
Stainless Steel	Beryllium-copper	0.026305
Stainless Steel	Chromium-Vanadium	0.026279
Stainless Steel	Inconel 750	0.026277
Stainless Steel	Spring Steel	0.026285
Carbon-steel	Beryllium-copper	0.025424
Carbon-steel	Chromium-Vanadium	0.0254
Carbon-steel	Inconel 750	0.025398
Carbon-steel	Spring Steel	0.25405

Table 4.4: Variation of Von-misses Strain

Component mtl	Spring mtl	min	Max
Al-Alloy	Beryllium-copper	2.4258e-10	0.0013452
Al-Alloy	Chromium-Vanadium	7.4458e-11	0.0013408
Al-Alloy	Inconel 750	8.8275e-11	0.0013404
Al-Alloy	Spring Steel	5.2688e-11	0.0013418
Stainless Steel	Beryllium-copper	1.1399e-10	0.00049891
Stainless Steel	Chromium-Vanadium	1.1399e-10	0.00049891
Stainless Steel	Inconel 750	1.135e-10	0.00049886
Stainless Steel	Spring Steel	1.1434e-10	0.00049905
Carbon-steel	Beryllium-copper	1.016e-10	0.0004848432
Carbon-steel	Chromium-Vanadium	9.6351e-11	0.000048432
Carbon-steel	Inconel 750	9.3827e-11	0.00048427
Carbon-steel	Spring Steel	1.029e-10	0.00048445

Table 4.4: Variation of Von-misses Stresses

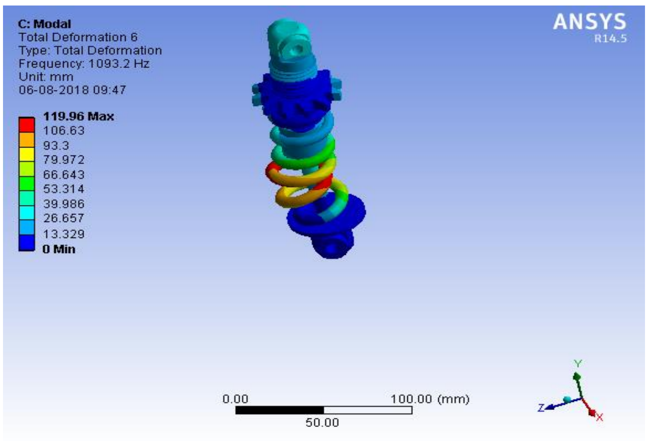
Component mtl	Spring mtl	min	Max
Al-Alloy	Beryllium-copper	1.210e-5	94.811
Al-Alloy	Chromium-Vanadium	5.2522e-6	94.5
Al-Alloy	Inconel 750	6.203e-6	94.473
Al-Alloy	Spring Steel	3.6635e-6	94.575
Stainless Steel	Beryllium-copper	1.6908e-5	95.67
Stainless Steel	Chromium-Vanadium	1.4439e-5	95.563
Stainless Steel	Inconel 750	1.4223e-5	95.554
Stainless Steel	Spring Steel	1.5038e-5	95.589
Carbon-steel	Beryllium-copper	1.6816e-5	96.221
Carbon-steel	Chromium-Vanadium	1.4626e-5	96.113
Carbon-steel	Inconel 750	1.422e-5	96.103
Carbon-steel	Spring Steel	1.5219e-5	96.139

V. CONCLUSIONS

- The total deformation is minimum (i.e 0.025398 mm) for Carbon-steel and Inconel 750 material combination with a least Von-misses strain i.e 9.3827e-11 , maximum of 0.00048427 and with a minimum stress of 1.422e-5Mpa , maximum stress of 96.103Mpa.
- So, the carbon steel and inconel 750 can sustain any shock loads under the max. design load which we considered.

VI. MODAL ANALYSIS

- In Modal Analysis we taken 10 modes with different frequencies with above mentioned materials varying gradually and every mode record a Total deformation. Here shows total deformation of shock absorber in 10 modes with different frequencies.



MODES	FREQUENCY (in Hz)	Total Deformation (in MM)
Mode 1	151.78	70.652
Mode 2	157.86	70.628
Mode 3	810.26	98.509
Mode 4	880.22	146.25
Mode 5	1093.2	119.96
Mode 6	1153.6	149.2
Mode 7	1249.8	179.23
Mode 8	1307.6	165.01
Mode 9	1484.1	157.51
Mode 10	1563.6	131.78

From above 10 Modes the Shock Absorber total deformation varies with different frequencies and I observed that at mode 5 the total deformation decreased compared to mode 4 and also mode 6 which is gradually increased, so the Carbon steel with Inconel 750 Shock Absorber is suitable up to 1000Hz frequency (Shock loads).

BIBLIOGRAPHY

[1]. Chinnamahammad bhasha, N. Vijay rami reddy, B. Rajnaveen, "DESIGN AND ANALYSIS OF SHOCK ABSORBER", International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 - 0056 , p-ISSN: 2395-0072, Volume: 04 Issue: 01 | Jan - 2017 ,page 201-207.

[2]. Mr. Sudarshan Martande1 , Mr. Y. N. Jangale2 , Mr. N.S. Motgi, "DESIGN AND ANALYSIS OF SHOCK ABSORBER", International Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 2, Issue 3, March 2013 ISSN 2319 - 4847, page 195-199.

[3]. Syambabu Nutalapati, "STRCTURAL ANALYSIS OF SHOCK ABSORBER BY USING ANSYS", IJER, VOLUME 3, ISSUE 6, DEC-2015, PAGE NO. 588-608.

[4]. Pinjarla.Poornamohan1, Lakshmana Kishore.T, "DESIGN AND ANALYSIS OF A SHOCK ABSORBER", IJRET: International Journal of Research in Engineering and Technology ISSN: 2319-1163, Volume: 01 Issue: 04 | Dec-2012, page..no 578-592.

[5]. Rahul Tekade1, Chinmay Patil , "Structural and Modal Analysis of Shock Absorber of Vehicle", International Journal of Engineering Trends and Technology (IJETT) – Volume 21 Number 4 – March 2015, ISSN: 2231-5381, Page 173-186.

[6]. Johnson, Davis Jose, Anthony Tony, "DESIGN AND ANALYSIS OF A SHOCK ABSORBER", International Journal of Scientific & Engineering Research, Volume 7, Issue 3, March-2016 19 ISSN 2229-5518, page.19-23.

[7]. Vijay Barethiye, G. Pohit , A. Mitra, "A combined nonlinear and hysteresis model of shock absorber for quarter car simulation on the basis of experimental data". Engineering Science And Technology, 2017, Page.No. 1610-1622.

[8]. W.ShivarajSingh, N.Srilatha ,“ Design and Analysis of Shock Absorber: A Review", science direct, materials today proceedings, Elsevier Ltd Volume 5, Issue 2, Part 1, 2018, Pages 4832-4837.

[9]. Xiao-HongLong[ab], Yong-TaoMa[a], RongYue[a], JianFan[ab], " EXPERIMENTAL STUDY ON IMPACT BEHAVIOUR OF RUBBER SHOCK ABSORBERS ". Volume 173, 10 June 2018, Pages 718-729. Elsevier Ltd.

[10]. MarouaneBenaziz[ab]SamuelNacivet[b]FabriceThouverez[a], "A SHOCK ABSORBER MODAL FOR STRUCTURE-BONE NOISE ANALYSES". ,Volume 349, 4 August 2015, Pages 177-194, Elsevier Ltd.

[11]. DheemanBhuyan,KaushikKumar, "COMPUTATIONAL FLUID FLOW ANALYSIS OF BASE VALVE FOR TWIN TUBE SHOCK ABSORBERS", Science Direct, Volume 4, Issue 2, Part A, 2017, Pages 2308-2313, Elsevier Ltd.

[12]. Tongyi Xu, Ottawa, Canada, "DESIGN AND ANALYSIS OF A SHOCK ABSORBER WITH A VARIABLE MOMENT OF INERTIA FLYWHEEL FOR PASSIVE VEHICLE SUSPENSION" A thesis submitted to the Faculty of Graduate and Postdoctoral Studies in Applied Science in Mechanical Engineering, 2013.

[13]. Dheeman Bhuyan, Kaushik Kumar, "3D CAD Modelling and Computational Fluid Analysis of Piston Valve of Twin Tube Shock Absorbers", materials today proceedings, Volume 4, Issue 8, 2017, Pages 7420-7425, Elsevier Ltd.

[14]. Piotr Czop, Damian S Ławik, "A high-frequency first-principle model of a shock absorber and servo-hydraulic tester", Mechanical Systems and Signal Processing proceedings , Volume 25, Issue 6, August 2011, Pages 1937-1955, Elsevier Ltd.

[15]. QinTian[a], Toshiro Hayashikawa[b], Wei-XinRen[c], "Effectiveness of shock absorber device for damage mitigation of curved viaduct with steel bearing supports", Engineering Structures proceedings ,Volume 109, 15 February 2016, Pages 61-74, Elsevier Ltd.

[16]. BogdanPawłowski[a],PiotrBała[ab],JanuszKrawczyk[a],Milena Stępień[b],TomaszŚleboda[a] "Failure analysis of shock absorber tubes", Engineering Failure Analysis, Volume 82, December 2017, Pages 533-539, Elsevier Ltd.