Design and Analysis of Shock Absorber using ANSYS Workbench

C. Sai Kiran

[1]Asst. Professor, CVR College of Engineering/Mechanical Engg. Department, Hyderabad, India
Email: csaikiran001@gmail.com

Abstract: In this paper, a shock absorber is designed and analyzed which is useful for damping shock impulse and dissipating kinetic energy. Shock absorber is a critical part of the suspension system, which is used to connect the vehicle to the wheels. The purpose of the work is to model a shock absorber which will be able to improve the ride quality by reducing the amplitude of disturbances caused by a bump road. Shock absorber is designed in CREO software. Analysis of shock absorber was performed by using ANSYS software and this analysis helps to predict the shock absorber failure when an external load acts on it.

Index Terms: Shock absorber, Shock impulse, Von-mises stress, ANSYS.

I. INTRODUCTION

Whenever any vehicle crosses a bump on the road, shock impulse is generated which will affect the passengers travelling in the vehicle Therefore, shock absorber or damper is a critical part of a suspension system used to dissipate kinetic energy and damp shock impulse. Without shock absorbers, the vehicle will bounce ride. A shock absorber absorbs sudden shocks generated by the uneven surface of the road and makes the ride smooth and comfortable.

Johnson et al. [1] has created a shock absorber design for carrying loads of a vehicle. The shock absorber is modelled in CATIA V5 software. Structural analysis is performed by varying the material in ANSYS Mechanical APDL software. After modelling the shock absorber, boundary conditions are applied. Von-mises stress and deformation values are observed in the results.

Sudarshan et al. [2] has developed a new methodology which allows designing the components of a shock absorber by using FEM. In production of shock absorbers, it is difficult to know the accuracy of shock absorber which doesn't fail. The shock absorber is modelled by using CAD software and analysed in ANSYS workbench by considering the weight of vehicle. In the results, deflection and stress induced in the shock absorber are observed.

Bhasha et al. [3] has designed a 3D model of shock absorber by using CATIA V5 R21 and changed the thickness of spring. A shock absorber reduces the effect of shocks while travelling on a rough road and increases the ride comfort and quality by reducing the amplitude of disturbances. Structural and modal analysis is performed on shock absorber by considering different materials for spring by using ANSYS software. Structural analysis was performed to validate the strength of the shock absorber. To determine the displacements for different frequencies, modal analysis was performed.

Chavhan et al. [4] has designed a shock absorber of pleasure vehicle. The shock absorber is modelled using Pro-E software. By using ANSYS software, static and dynamic analysis is performed by changing materials for spring. In ANSYS, the results of deflection and von-mises stress are observed.

Mallesh et al. [5] has designed a 3D model of shock absorber by using CATIA V5 20 software and structural analysis of shock absorber is performed by using ANSYS 15.0 software. Suspension system consists of springs and dampers for passenger's safety and for a comfortable ride. A shock absorber consists of spring, top and bottom part. The loads are applied on shock absorber to know the results of total deformation, equivalent stress and equivalent strain.

Mohan et al. [6] has modelled a shock absorber using Pro/ENGINEER software. Structural and modal analysis is performed by considering the vehicle weight and person weight. Modal analysis is performed to know the displacements and frequencies for number of mode shapes.

Achyut et al. [7] has designed a 3D model of shock absorber by using Pro/ENGINEER software. Shock absorber consists of a sliding piston in a cylinder. The cylinder can be filled by either fluid or air. Analysis is performed in ANSYS. The results of natural frequency, total deformation and shear stress are observed.

Manga et al. [8] has modelled a shock absorber using CATIA V5 R20. A shock absorber uses a soft spring for controlling the rate of suspension movement in response to bumping. Structural and modal analysis of shock absorber is performed by using ANSYS. Modal analysis is performed for different frequencies to understand deformations for ten different mode shapes.

Prasad et al. [9] has focused on developing new correlate methodologies which enables to design different parts of a shock absorber by FEM tools. All the different parts of shock absorbers are modelled and assembled in CAD software. Structural analysis is performed in ANSYS 13.0 software.

Christopher et al. [10] has designed and analysed the shock absorber performance by varying the diameter of the spring. The modelling of shock absorber is performed by using Pro-E and analysis by using ANSYS software. The analysis is performed by considering number of persons, different loads and bike mass.

Durmus et al. [11] has created a shock absorber model by using CATIA software. Modal and structural analyses are performed by considering different materials for shock absorber. The analysis is performed by considering four person's weight, vehicle weight and different loads. The

results were analysed and optimized in Minitab software by using Taguchi method.

Sunil et al. [12] has designed a 3D model of a shock absorber with helical spring and wave spring by using CREO software. Structural and modal analysis is performed by considering the bike and passengers weight by using ANSYS software. To determine the strength of the shock absorber, structural analysis is performed. Modal analysis is performed to determine the displacements and frequency of each number of mode shapes.

Ramanjaneyulu et al. [13] has designed the shock absorber of hero honda bike by using Solidworks software. By considering different loading conditions, structural and modal analysis is performed by using ANSYS software.

Akhil et al. [14] has modelled a shock absorber with different tapper angles for a spring by using CATIA-V5. To determine stresses and deflections, structural analysis is performed. The results are compared with existing spring model to verify the best spring design of shock absorber.

Chatterjee et al. [15] has modelled a shock absorber in Solidworks. The analysis of the shock absorber is performed in Abaqus and Ansys software. Shear stress and deflection results are observed to suggest the best material.

A. Different Types of Shock Absorber

Shock absorbers connect vehicles to its wheels. A shock absorber is coupled with a spring to convert sudden shock waves into oscillatory motion. Shock absorbers provide a comfortable ride and stability to the vehicle on the uneven surface of the road[1].
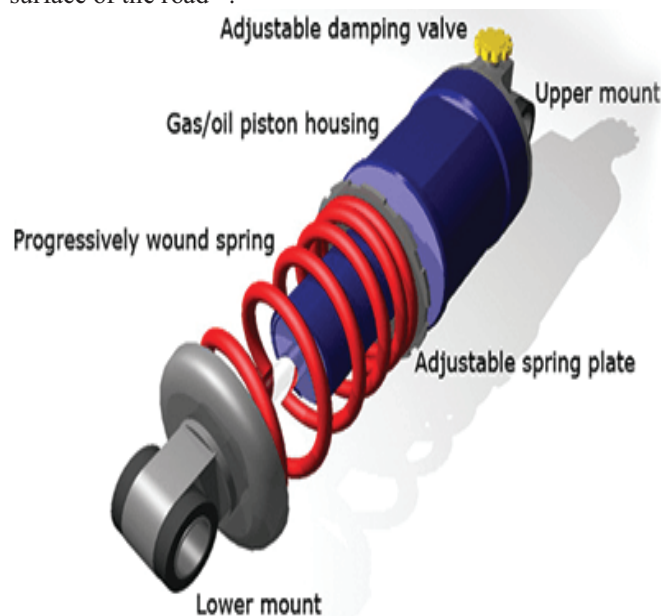

Figure 1.   Shock Absorber and its Parts

Shock absorber is represented in Fig. 1. The main parts of a shock absorber are spring, adjustable spring plate, gas/oil piston housing, damping valve, upper and lower mount[2]. Some of the important types of shock absorbers are given below[3]:

1. Mono tube damper shock absorber.
2. Twin tube damper shock absorber.
3. Air shock absorber.
4. Electric shock absorber.

B. Working Principle of a Shock Absorber

Whenever a vehicle hits a bump on the road, the spring of the shock absorber to coil and uncoil. The energy of the spring is transferred to the shock absorber through the upper mount, down through the piston rod and into the piston.

The working principle of a shock absorber is shown in Fig. 2. The shock absorber works in extension cycle and the compression cycle. In the extension cycle, the piston moves upwards. In the compression cycle, the piston moves down and compresses the spring. The compression cycle controls the vehicle's unsprung weight and extension cycle controls the sprung weight of the vehicle.
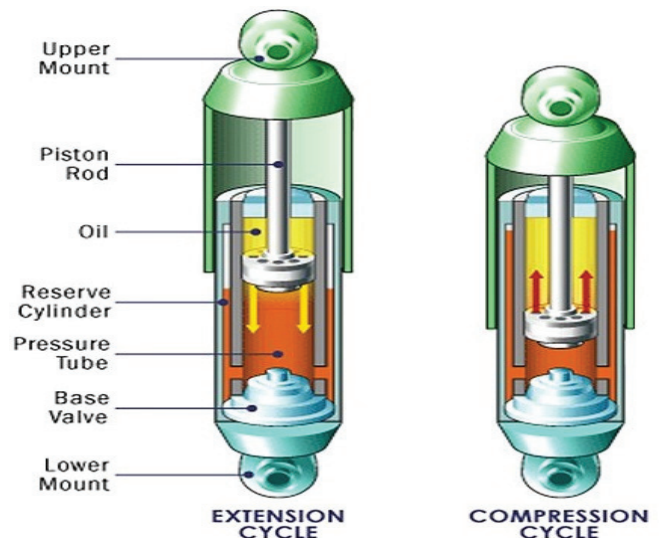

Figure 2.   Working Principle of a Shock Absorber

C. Shock absorber Material

Shock absorbers are generally made of materials which are very strong and suitable to withstand heavier impact loads on it. Carbon steel, Stainless steel and Aluminum alloy are the materials[8] selected for shock absorber as shown in Table I.

TABLE I.
MATERIAL PROPERTIES OF STEEL

S. No	Properties	Carbon Steel	Stainless Steel	Aluminum Alloy
1.	Density (Kg/m^3)	7,870	7,850	3,630
2.	Young's Modulus (GPa)	205	203	77.9
3.	Yield Strength (MPa)	360	310	279
4.	Tensile Strength (MPa)	440	510	344
5.	Poisson's Ratio	0.29	0.275	0.327

II. MODELLING AND FINITE ELEMENT ANALYSIS

A. Shock absorber Model

The important parts of a shock absorber are upper mount, piston rod, cylinder and lower mount. All the different parts of the shock absorber are modelled separately in CREO software and all the individual parts of the shock absorber are assembled in the CREO as shown in Fig. 3

Figure 3. Assembled Model of Shock Absorber in CREO

B. Elememt Type

The element type selected for shock absorber is SOLID 186. It is a 20-node higher order solid element which has three degrees of freedom per node. The three degrees of freedom are nodal x, y and z translations.

It exhibits quadratic displacement behavior and have spatial orientation. SOLID 186 support large strain capabilities, plasticity, large deflection, hyper elasticity, stress stiffening and creep. SOLID 186 have capability for simulating deformations of incompressible elastoplastic materials and incompressible hyper-elastic materials.

C. Meshing

In meshing, the created 3D model is divided into the certain number of divisions or elements for accurate analysis result. By applying meshing on the model, we can determine the effectiveness and efficiency of any analysis. An automated mesh is generated on the created model which is shown in Fig. 4.
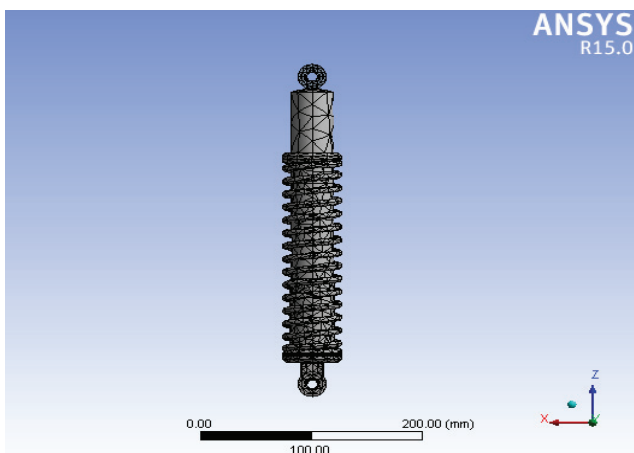

Figure 4. Meshing of Shock Absorber

In the automatic mesh, a fine mesh is applied to achieve precise and accurate results. Instead of using a fine mesh on all the components of the model, coarse mesh is applied on larger area and fine mesh is applied only on the area of higher stress concentration.

D. Applying Loads

On the lower mount of the shock absorber, a fixed support is assigned to withstand the forces acting on the shock absorber as shown in Fig. 5.
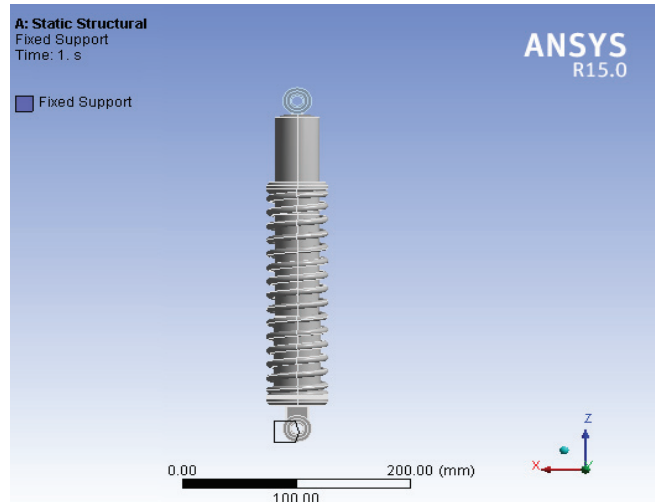

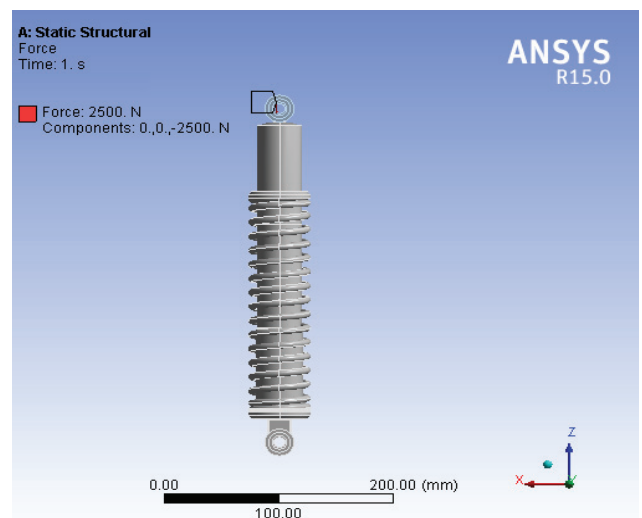Figure 5. Fixed Support on the Lower Mount of Shock Absorber

Figure 6. Applying Force on Upper Mount of Shock Absorber

Whenever a certain external load is applied on the upper mount of a shock absorber, the shock absorber cylinder moves down and compresses the spring. For applying the load on the shock absorber, the weight of the vehicle with passengers is calculated in Kg and the weight is converted into force. A force of 2500 N is applied on the upper mount of the shock absorber[4] as shown in Fig. 6.

III. RESULTS AND DISCUSSIONS

After assigning fixed support on the lower mount and applying the static load on the upper mount of the shock

absorber, structural analysis is performed on the shock absorber for three different materials in ANSYS workbench to determine the total deformation and von-mises stress. The following results were observed in the analysis.
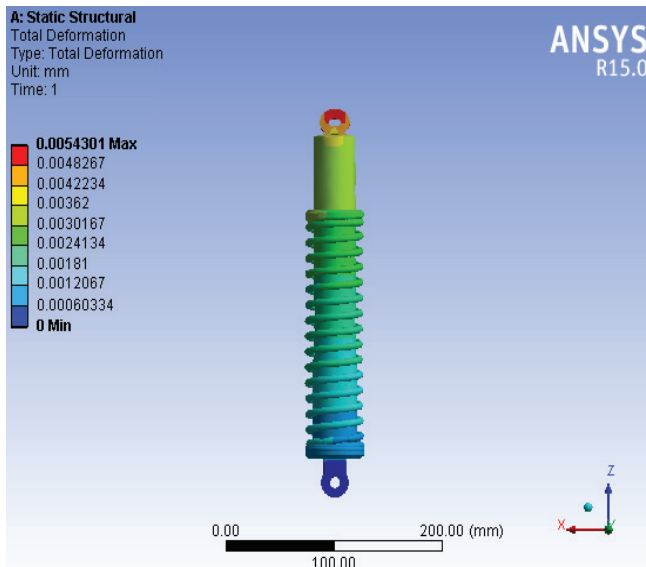
A. Total Deformation of Shock absorber

Figure 7.   Total Deformation of Carbon Steel Material

After performing structural analysis by applying the load on shock absorber for carbon steel material, a maximum total deformation of 0.0054 mm and the minimum total deformation of 0 mm are observed from the Fig. 7.
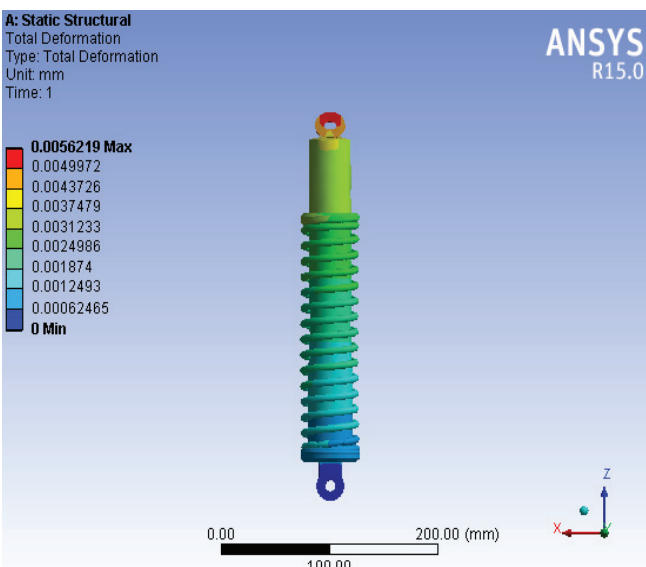

Figure 8.   Total Deformation of Stainless Steel Material

After performing structural analysis by applying the load on shock absorber for stainless steel material, a maximum total deformation of 0.0056mm and the minimum total deformation of 0 mm are observed from the Fig. 8.

After applying the load on shock absorber, structural analysis is performed on aluminum alloy material. A maximum total deformation of 0.0152mm and the minimum total deformation of 0 mm are observed from the Fig. 9.
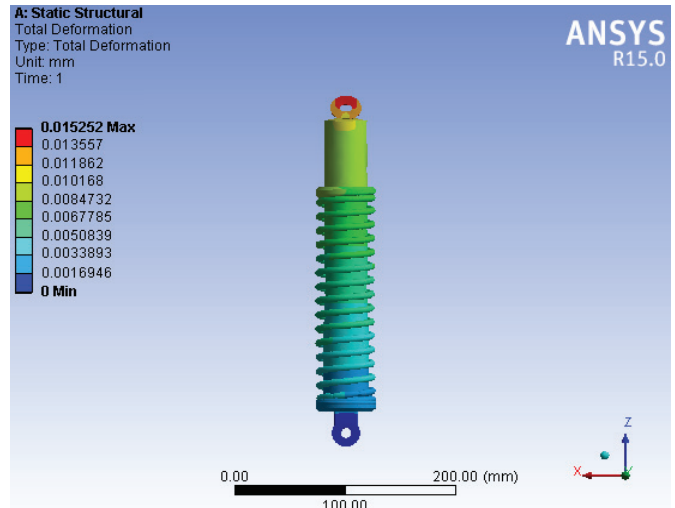

Figure 9.   Total Deformation of Aluminum Alloy Material

B. Von-mises Stress of Shock absorber

After performing structural analysis by applying the load on shock absorber for carbon steel material, maximum von-mises stress of 21.09MPa and minimum von-mises stress of 0.0197Pa are observed from the Fig. 10.
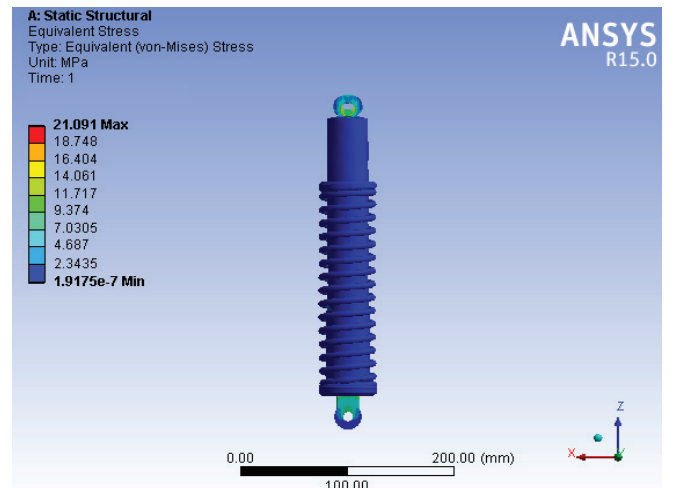

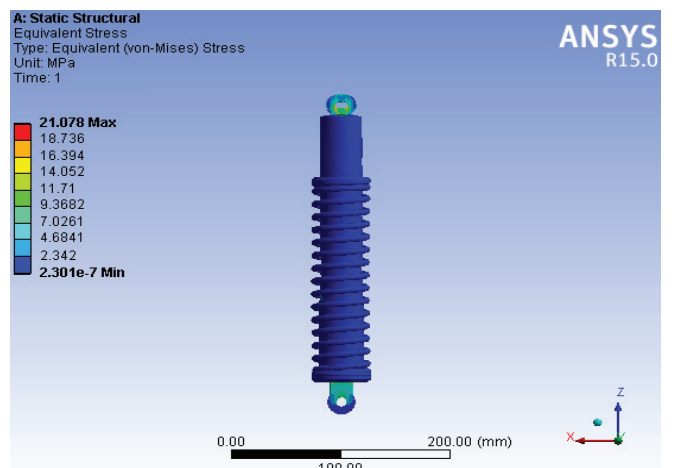Figure 10. Von-mises Stress of Carbon Steel Material

Figure 11. Von-mises Stress of Stainless Steel Material

After performing structural analysis by applying the load on shock absorber for stainless steel material, maximum von-mises stress of 21.07MPa and minimum von-mises stress of 0.2301Pa are observed from the Fig. 11.

After performing structural analysis by applying the load on shock absorber for aluminum alloy material, maximum von-mises stress of 21.05 MPa and minimum von-mises stress of 0.025Pa are observed from the Fig. 12.
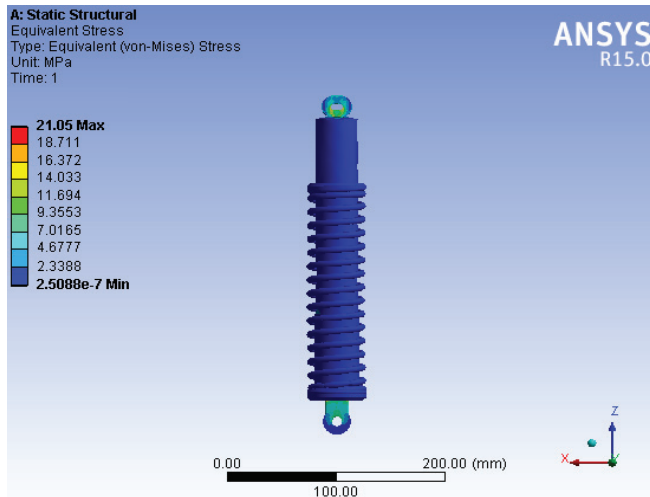

Figure 12. Von-mises Stress of Aluminum Alloy Material

After performing structural analysis by applying the load on shock absorber, the graph of total deformation for three different materials is observed from the Fig. 13.
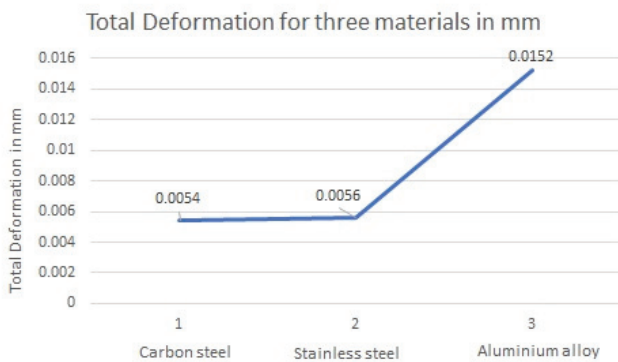

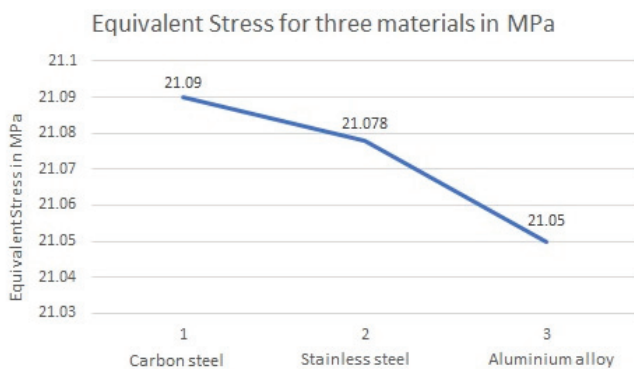Figure 13. Total Deformation Graph for Different Materials

Figure 14. Equivalent Stress Graph for Different Materials

After performing structural analysis by applying the load on shock absorber, the graph of von-mises stress for three different materials is observed from the Fig. 14.

IV. CONCLUSIONS

In this paper, CREO software is used for modelling the shock absorber and analysis of shock absorber with a force of 2500 N is analysed by using ANSYS software. The von-mises stress and total deformation of the shock absorber are analysed.

TABLE II.
RESULTS COMPARISON FOR SHOCK ABSORBER MATERIAL

Material	Total Deformation (mm)	Equivalent Stress(MPa)
Carbon Steel	0.0054	21.09
Stainless Steel	0.0056	21.078
Aluminum Alloy	0.0152	21.05

From the Table II, it is observed that the maximum total deformation is observed in aluminium alloy and the minimum total deformation is observed in carbon steel material. Maximum von-mises stress is observed in carbon steel and the minimum von-mises stress is observed in aluminium alloy material. The values of von-mises stress and total deformation of the shock absorber are within the limits. Therefore, modelled shock absorber has long life and safe to use.

In future scope, different dimensions for a shock absorber can be modelled by considering advanced materials like composites and by assigning different loading conditions for performing analysis.

REFERENCES

[1] Johnson, Davis Jose and Anthony Tony, "Design and analysis of a shock absorber," *International Journal of Scientific and Engineering Research*, vol. 7, Issue 3, ISSN 2229-5518 pp. 19–23, March 2016.
[2] Sudarshan Martande, Y. N. Jangale and N. S. Motgi, "Design and analysis of shock absorber," *International Journal of Application or Innovation in Engineering and Management*, vol. 2, Issue 3, ISSN 2319-4847 pp. 195–199, March 2013.
[3] A. Chinnamahammad Bhasha, N. Vijay Rami Reddy and B. Rajnaveen, "Design and analysis of shock absorber," *International Journal of Engineering and Technology*, vol. 4, Issue 1, pp. 201–207, January 2017.
[4] G. R. Chavhan, S. W.Burande and Dr. L. P. Dhole, "Analysis of shock absorber using different material of spring," *International Journal of Advanced Engineering Technology*, vol. 5, Issue 4, pp. 19–21, December 2014.
[5] Mallesh Jakanur, and Dr. S. Chakradhar Goud, "Structural static analysis of shock absorber," *International Journal of Advance Research in Science and Engineering*, vol. 5, Issue 8, pp. 248–255, August 2016.
[6] Pinjarla Poornamohan, and T. Lakshmana Kishore, "Design and analysis of shock absorber," *International Journal of Research in Engineering and Technology*, vol. 1, Issue 4, pp. 578–592, December 2012.
[7] Achyut P. Banginwar, Nitin D. Bhusale and Kautuk V. Totawar, "Design and analysis of shock absorber using FEA

tool," *International Journal of Engineering Research and Development*, vol. 10, Issue 2, pp. 22–28, February 2014.

[8] Manga Hymanjali, Elumagandla Surender, and Nalla Suresh, "Design and analysis of shock absorber," *International Journal of Innovative Science and Research Technology*, vol. 3, Issue 8, pp. 420–430, August 2018.

[9] V. Hari Prasad, Upparpalli Guna, and Dr. D. Vijayaganapathy, "Design and analysis of a shock absorber spring for automobiles," *International Journal of Pure and Applied Mathematics*, vol. 120, Issue 6, ISSN 1314-3395 pp. 3955–3963, June 2018.

[10] J. Prince Jerome Christopher, and R. Pavendhan, "Design and analysis of two-wheeler shock absorber coil spring," *International Journal of Modern Engineering Research*, pp. 133–140.

[11] Durmus Ali Bircan, and Abdul kadir Yasar, "Design, analysis and optimization of a shock absorber," *Journal of Agricultural Machinery Science,* vol. 10, Issue 4, pp. 293–299, August 2014.

[12] K. Raminaidu, K. Sunil Ratna Kumar, E. Venkateshwar Rao, and Ch. Lakshmi Pornima, "Design and analysis of wave spring for motar cycle shock absorber," *Anveshana's International Journal of Research in Engineering and Applied Sciences*, vol. 3, Issue 2, ISSN-2455-6300, pp. 171–176, February 2018.

[13] S. Ramanjaneyulu, B. Geetha Chandra Sekhar, and R. Rama Krishna, "Design, modeling and performance analysis of psd shock absorber using ansys," *International Journal of Current Engineering and Scientific Research*, vol. 5, Issue 4, ISSN-2393-8374, pp. 68–80, 2018.

[14] Gopireddy Akhil Kumar Reddy, and Dr. G. Maruthi Prasad Yadav, "Modeling and analysis of two wheeler shock absorber for optimum performance," *International Journal of Engineering Trends and Applications*, vol. 5, Issue 2, ISSN-2393-9516, pp. 7–13, March 2018.

[15] Sitangshu Chatterjee, and Subash Nandy, "Optimization of a shock absorber using finite element analysis," *International Journal of Science, Engineering and Technology Research*, vol. 7, Issue 8, ISSN: 2278-7798, pp. 564–568, August 2018.