

ANALYSIS FOUR WHEEL DRIVE SUSPENSION SYSTEM BY USING FEA

Prashant. M. Palled*¹, Raju. S. Matti*²

*¹M.Tech Student, Machine Design, Department Of Mechanical Engineering, BEC Bagalkot, India.

*²Assistant Pofessor, Department Of Mechanical Engineering, BEC Bagalkot, India.

ABSTRACT

Four-wheel drive (4WD) refers to vehicles with two axles providing torque to four axle ends. In the North American market, the term generally refers to a system optimized for off-road driving conditions. The term "4WD" is typically designated for vehicles equipped with a transfer case that switches between 2WD and 4WD operating modes, either manually or automatically.

In this work, a suspension system was modeled using a modeling software and then exported into a simulation software. The analysis on the suspension system was done in two parts. In the first part, the model was analyzed for different loads and four different materials (Stainless Steel AISI302, INCONEL 718, ASTM A227 Spring Steel and Beryllium Copper ASTM B197) to understand and find the optimum material to be used in the second part. The second part of the analysis is to understand the effect of change in the dimensions of the suspensions. The results of the analysis indicate that the change in the dimensions improve the performance of the suspension system to a certain degree. The change in the diameter of the cylinder reduced the stress acting on the whole system and the contribution of changing the spring stiffness has a lower effect than the change in the cylinder diameter.

Keywords: Finite Analysis, Investigation, Loads Applied .Cylinder Diameter And Spring Stiffness Variation. Research.

I. INTRODUCTION

Automobiles started off as self-propelled versions of animal-drawn carriages. Animal-drawn vehicles, on the other hand, were designed for slow speeds and lacked a suspension system capable of withstanding the higher speeds allowed by internal combustion engines. Modern vehicle suspension must meet a multitude of requirements. Four-wheel drive mechanism also known as 4x4, is a two-axled mechanism drivetrain which can deliver torque to all four wheels simultaneously.

"All-wheel drive" refers to a 4-wheel drive vehicle with torque supplied equally to each axles (AWD). However, "four-wheel drive" usually refers to a set of specialised components and functions, as well as an off-road application, which is more in line with modern usage.

Vehicles having two axles generating torque to four axle ends are referred to as four-wheel drive (4WD). The word primarily refers to a system geared for off-road driving situations in the North American market. The term "4WD" usually refers to vehicles that have a transfer case that can transition between 2WD and 4WD operating modes manually or automatically. Vehicle suspension must meet a number of standards that vary depending on the vehicle's working conditions (loaded & unloaded, acceleration & braking, level & uneven road, straight running & cornering). Suspension systems have two functions: they contribute to the vehicle's stability in handling and braking effectively for safety and driving pleasure, and they make vehicle passengers comfortable and reduce the road noise, bumps, and vibrations.

The suspension also guards against damage and wear to the vehicle and its attached systems. Suspension refers to the mechanism that connects a vehicle to its wheels and includes springs, shock absorbers, and linkages. A front and rear suspension of the vehicles may be designed differently.

A dependent suspension usually has a beam or live axle that keeps the wheels aligned to each other and perpendicular to the axle with the help of leaf springs.

An independent suspension system uses kinematic linkages and coil springs to allow wheels to rise and fall independently without affecting the opposing wheel. In this method, we are dealing with geometric model preparation, Finite element model preparation and analysis of the finite element model under the various loads and boundary conditions.

The ANSI (which stands for American National Standards Institute) explains an all-terrain vehicle (ATV) as a locomotive that rides on tyres with pressure less than the required number & has a seat that is straddled by the operator, and for steering control they have handlebars. It is designed to navigate a wide range of terrain than most other vehicles, as the name implies. Sport variants of ATVs are designed for performance rather than utility. An ATV must have light weight, have great power, adequate suspension, and a low centre of gravity to be successful in fast trail riding

II. METHODOLOGY

- Creation of CAD Model for the suspension system using SOLIDWORKS.
- Making of finite element model, using ANSYS based on the CAD model created using solidworks.
- Materials are AISI 302 ,INCONEL 718, BERYLLIUM COPPER and ASTM227SPRING STEEL and properties for the generated FE model.
- Loads are to be applied and also the boundary conditions.
- Analysis of the suspension system for different materials.
- Selection of optimum material for the suspension and varying suspension dimensions for optimum characteristics.
- After the analysis, the results are to be extracted and documented.

III. MODELING AND ANALYSIS

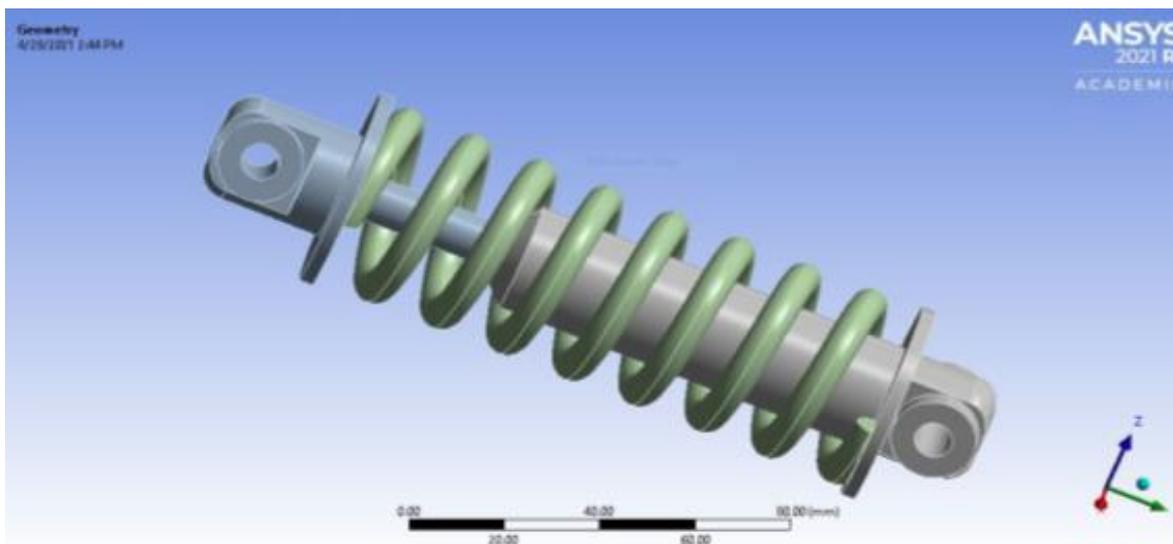


Figure 1: Suspension system Assembly

IV. RESULTS AND DISCUSSION

1 Stainless steel AISI 302

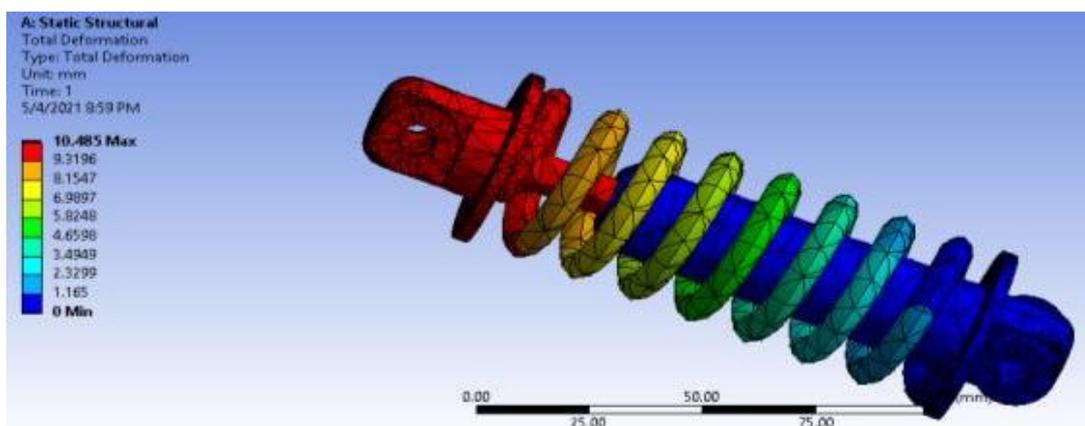


Figure 1: Total Deformation results for AISI 302 at 654N

Figure 1 shows the total deformation for the suspension system with material AISI 302 with loading at 654N. the plot reveals that the total deformation in the system is at 10.405mm and it occurs on the top of the system whereas the bottom of the suspension system is fixed. This high deformation is seen because the results include the spring and damper effect and the deformation in the component. A large percentage of the deformation is in the spring between the values 1.1mm and 8.1mm.

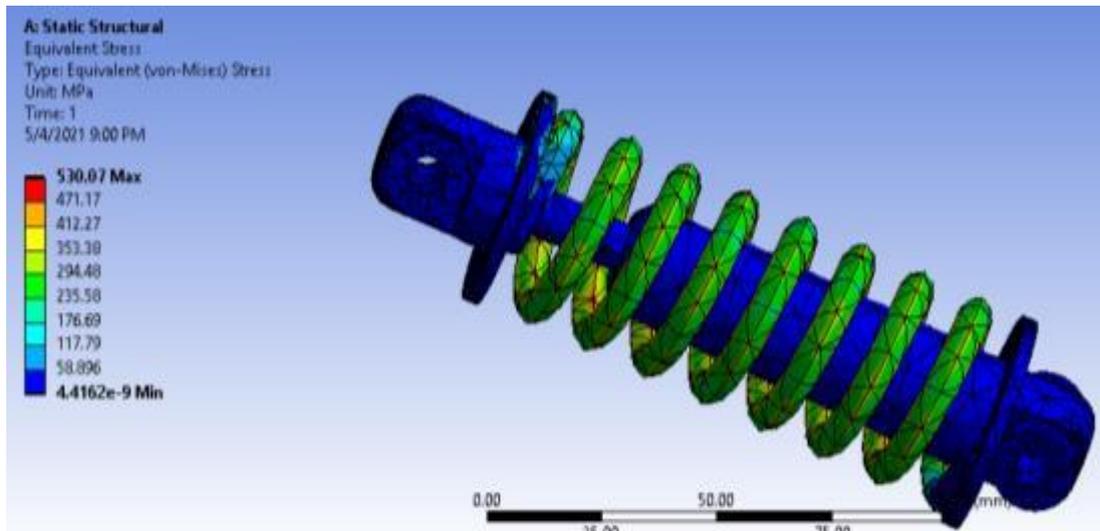


Figure 2: Von Mises Stress results for AISI 302 at 654N

Figure 2 gives the plot for the Von Mises stress developed in the suspension system with the material AISI 302 at 654N load. The results indicate that the maximum stress developed is in the springs of the system and rest of the components experience negligible forces. This is optimum because the load path for this system is through the springs and not any other components. The maximum value of stress is seen at 530MPa but a large portion of the system experiences stress in the range of 235.58MPa and 294.48MPa.

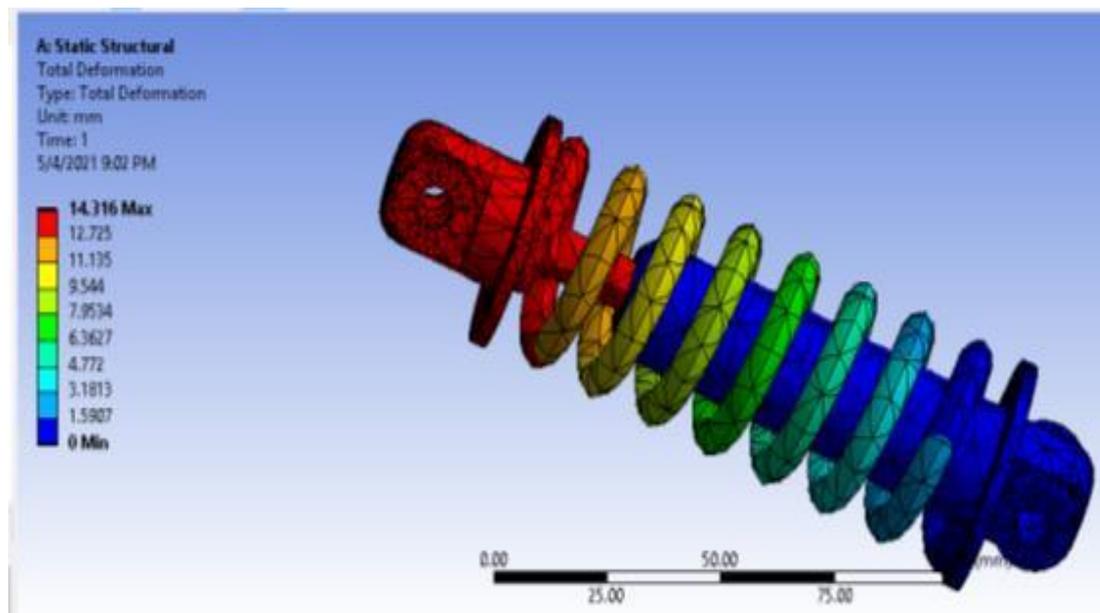


Figure 3: Total Deformation results for AISI 302 at 893N

Figure 3 shows the total deformation for the suspension system with material AISI 302 with loading at 893N. the plot reveals that the total deformation in the system is at 14.316mm and it occurs on the top of the system whereas the bottom of the suspension system is fixed. This high deformation is seen because the results include the spring and damper effect and the deformation in the component. A large percentage of the deformation is in the spring between the values 1.6mm and 11.135mm.

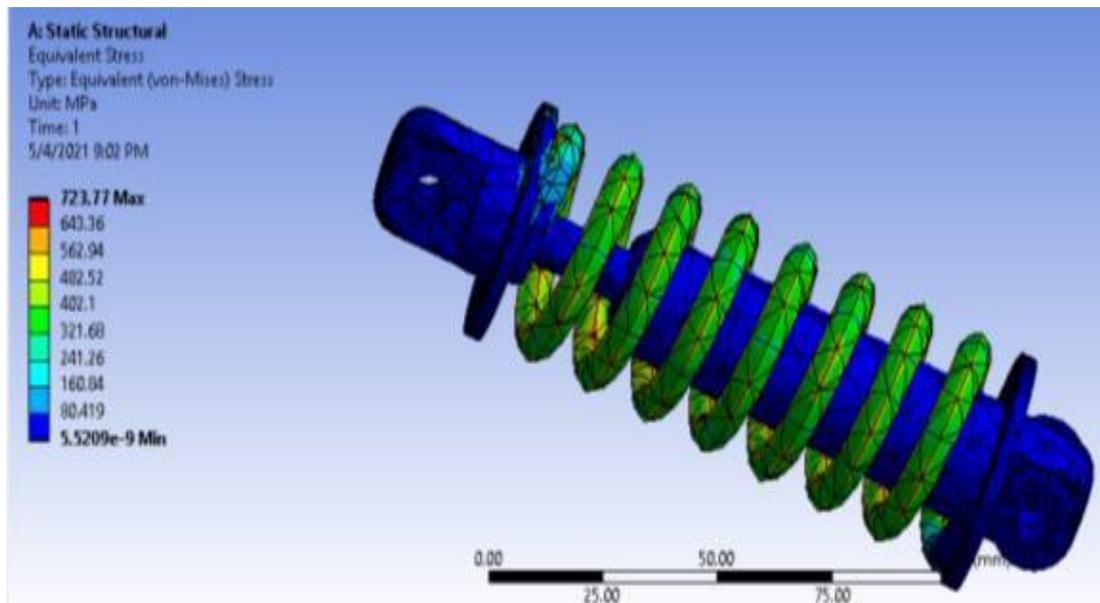


Figure 4: Von Mises Stress results for AISI 302 at 893N

Figure 4 gives the plot for the Von Mises stress developed in the suspension system with the material AISI 302 at 893N load. The results indicate that the maximum stress developed is in the springs of the system and rest of the components experience negligible forces. This is optimum because the load path for this system is through the springs and not any other components. The maximum value of stress is seen at 723.77MPa but a large portion of the system experiences stress in the range of 321.68MPa and 402.1MPa.

2. INCONEL 718

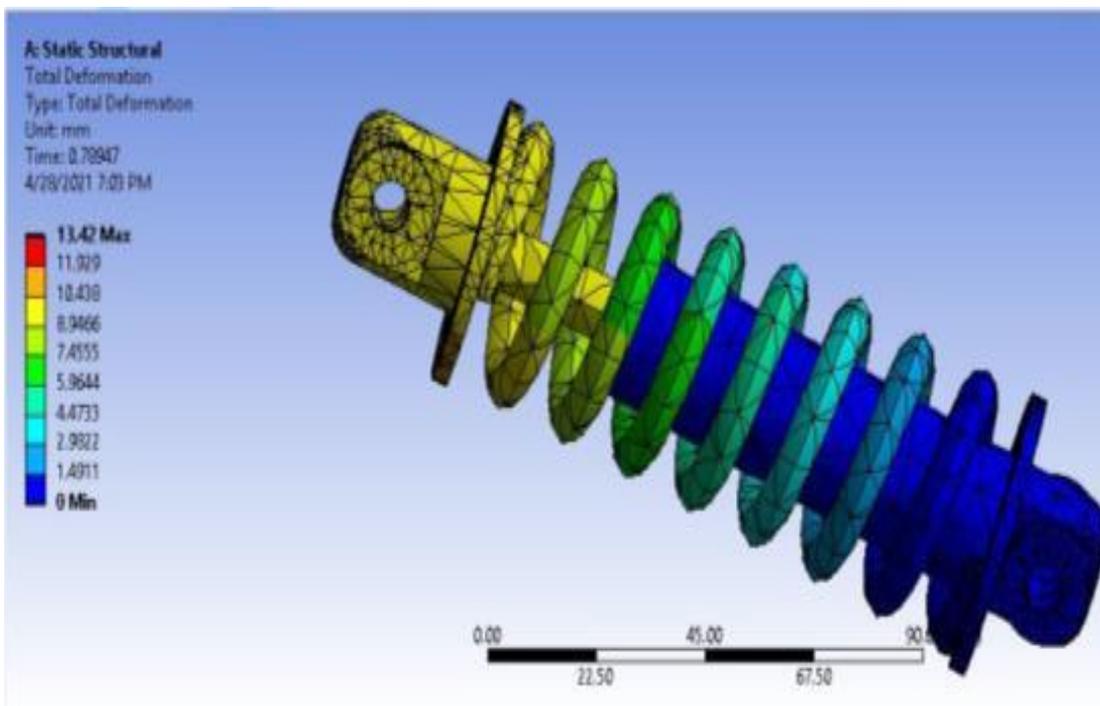


Figure 5: Total Deformation results for INCONEL 718 at 654N

Figure 5 shows the total deformation for the suspension system with material INCONEL 718 with loading at 654N. The plot reveals that the total deformation in the system is at 13.42mm and it occurs on the top of the system whereas the bottom of the suspension system is fixed. This high deformation is seen because the results include the spring and damper effect and the deformation in the component. A large percentage of the deformation is in the spring between the values 1.5mm and 10.5mm.

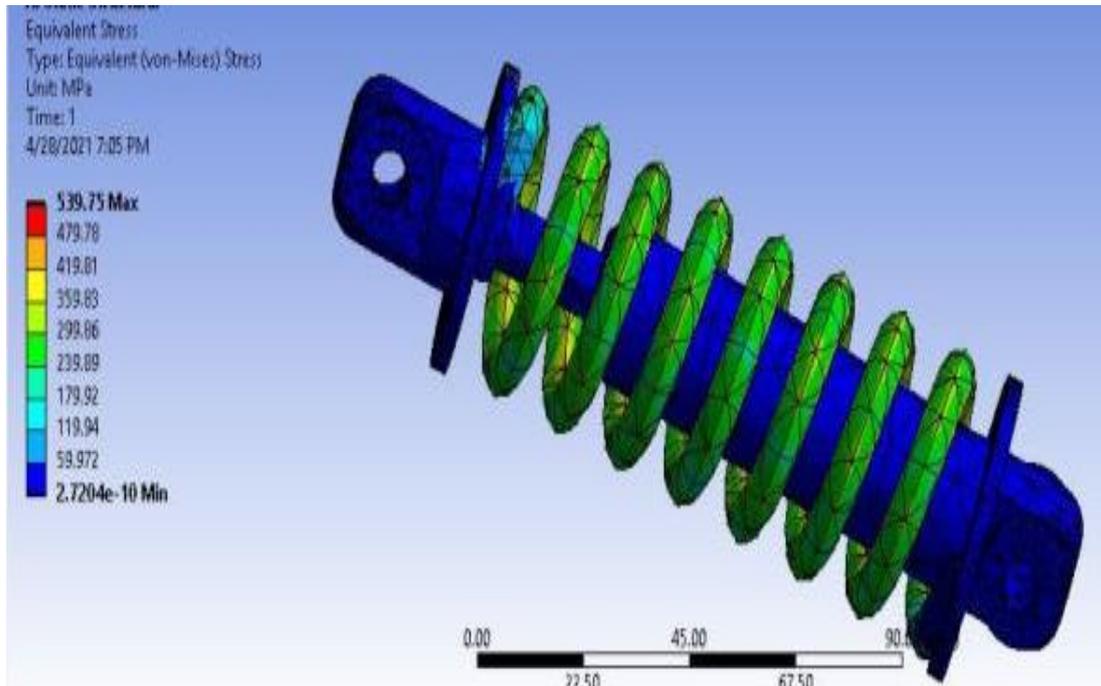


Figure 6: Von Mises Stress results for INCONEL 718 at 654N

Figure 6 gives the plot for the Von Mises stress developed in the suspension system with the material INCONEL 718 at 654N load. The results indicate that the maximum stress developed is in the springs of the system and rest of the components experience negligible forces. This is optimum because the load path for this system is through the springs and not any other components. The maximum value of stress is seen at 539.75MPa but a large portion of the system experiences stress in the range of 239.89MPa and 299.86MPa.

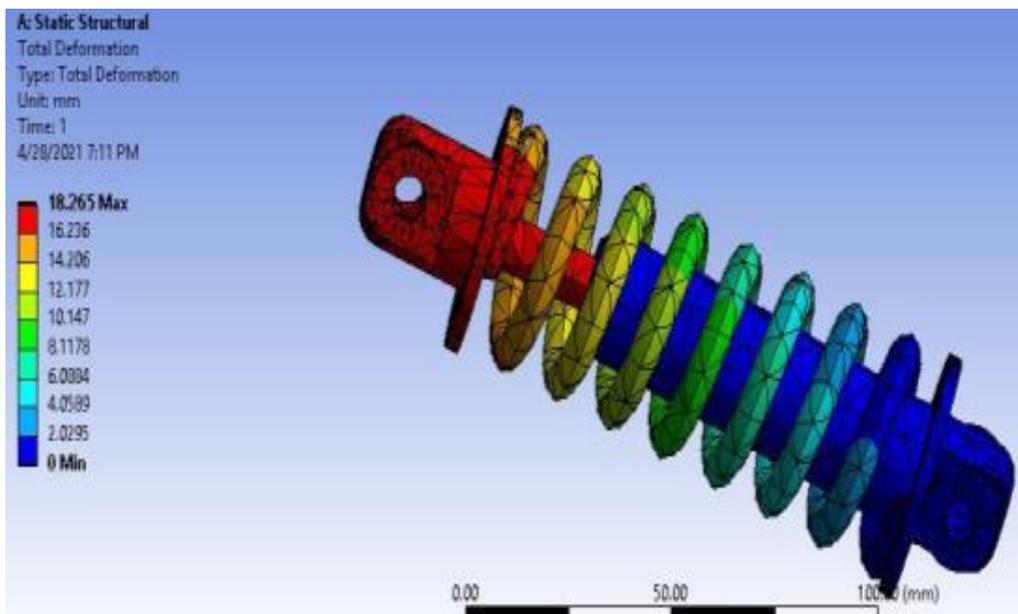


Figure 7: Total Deformation results for INCONEL 718 at 893N

Figure 7 shows the total deformation for the suspension system with material INCONEL 718 with loading at 893N. The plot reveals that the total deformation in the system is at 18.265mm and it occurs on the top of the system whereas the bottom of the suspension system is fixed. This high deformation is seen because the results include the spring and damper effect and the deformation in the component. A large percentage of the deformation is in the spring between the values 2.02mm and 14.206mm.

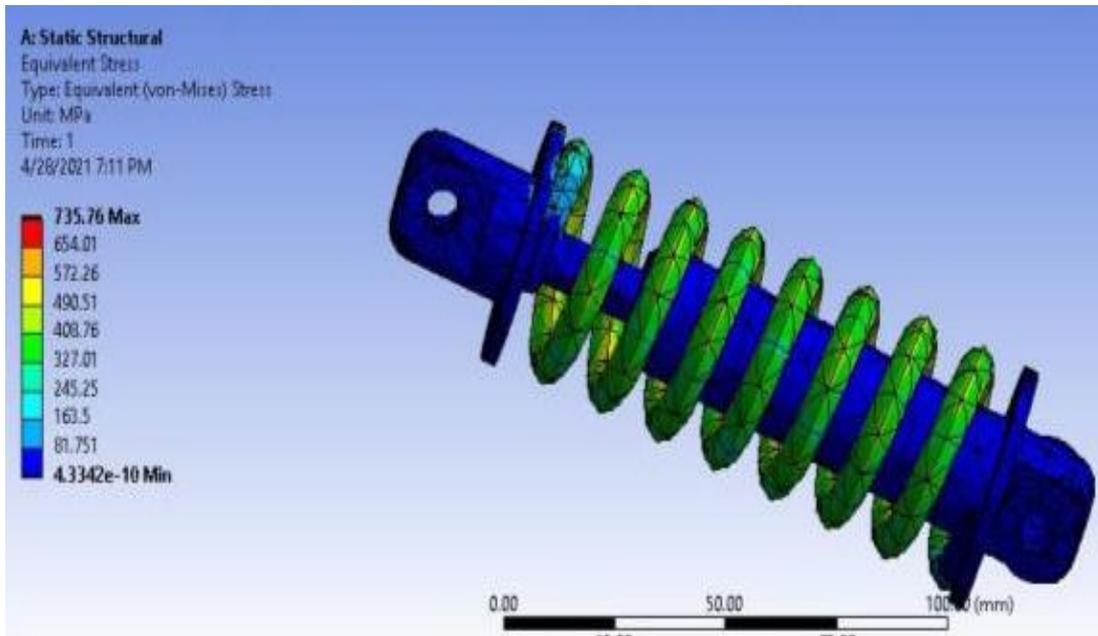


Figure 8: Von Mises Stress results for INCONEL 718 at 893N

Figure 8 gives the plot for the Von Mises stress developed in the suspension system with the material INCONEL 718 at 893N load. The results indicate that the maximum stress developed is in the springs of the system and rest of the components experience negligible forces. This is optimum because the load path for this system is through the springs and not any other components. The maximum value of stress is seen at 735.76MPa but a large portion of the system experiences stress in the range of 327.01MPa and 408.76MPa.

3. ASTM A227 Spring steel

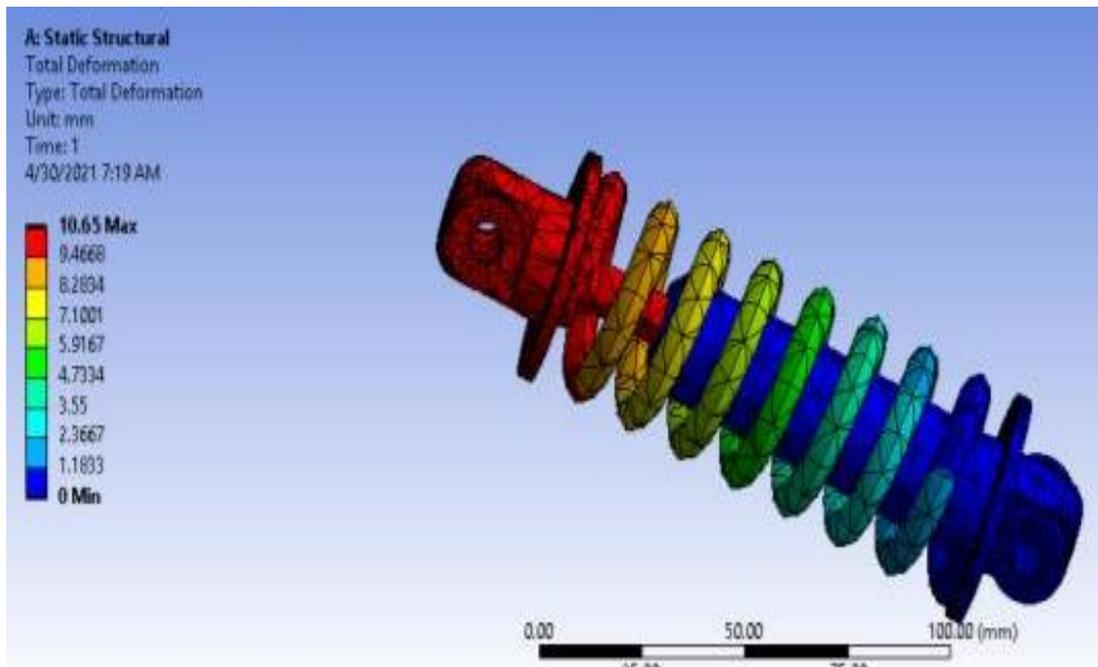


Figure 9: Total Deformation results for ASTM A227 Spring steel at 654N

Figure 9 shows the total deformation for the suspension system with material ASTM A227 Spring Steel with loading at 654N. The plot reveals that the total deformation in the system is at 10.65mm and it occurs on the top of the system whereas the bottom of the suspension system is fixed. This high deformation is seen because the results include the spring and damper effect and the deformation in the component. A large percentage of the deformation is in the spring between the values 1.18mm and 8.28mm.

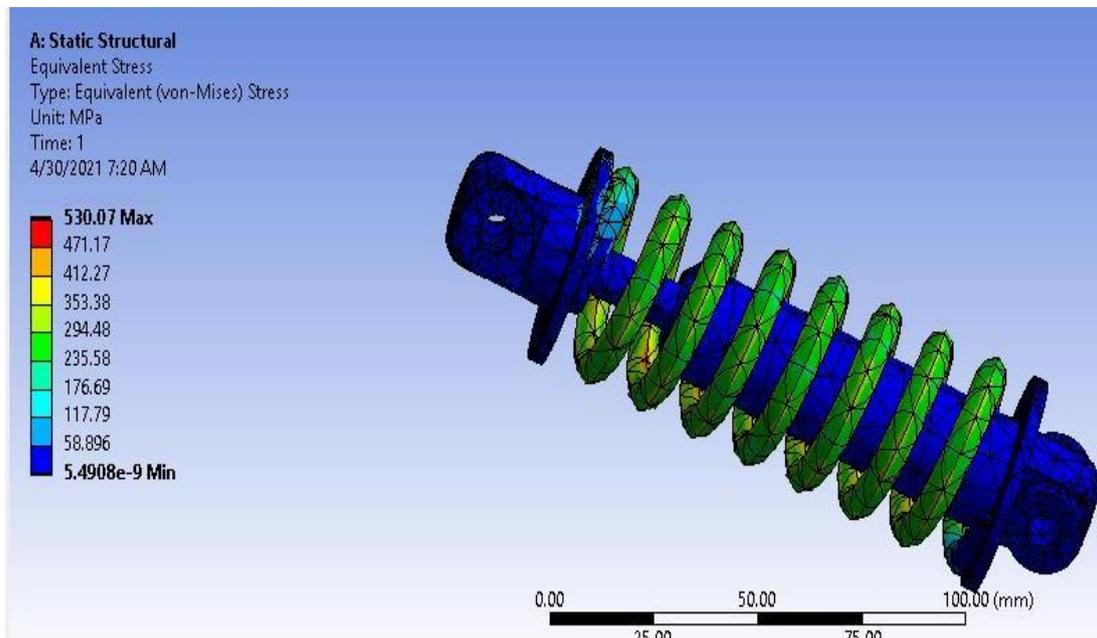


Figure 10: Von Mises Stress results for ASTM A227 Spring steel at 654N

Figure 10 gives the plot for the Von Mises stress developed in the suspension system with the material ASTM A227 Spring steel at 654N load. The results indicate that the maximum stress developed is in the springs of the system and rest of the components experience negligible forces. This is optimum because the load path for this system is through the springs and not any other components. The maximum value of stress is seen at 530.07MPa but a large portion of the system experiences stress in the range of 235.58MPa and 294.48MPa.

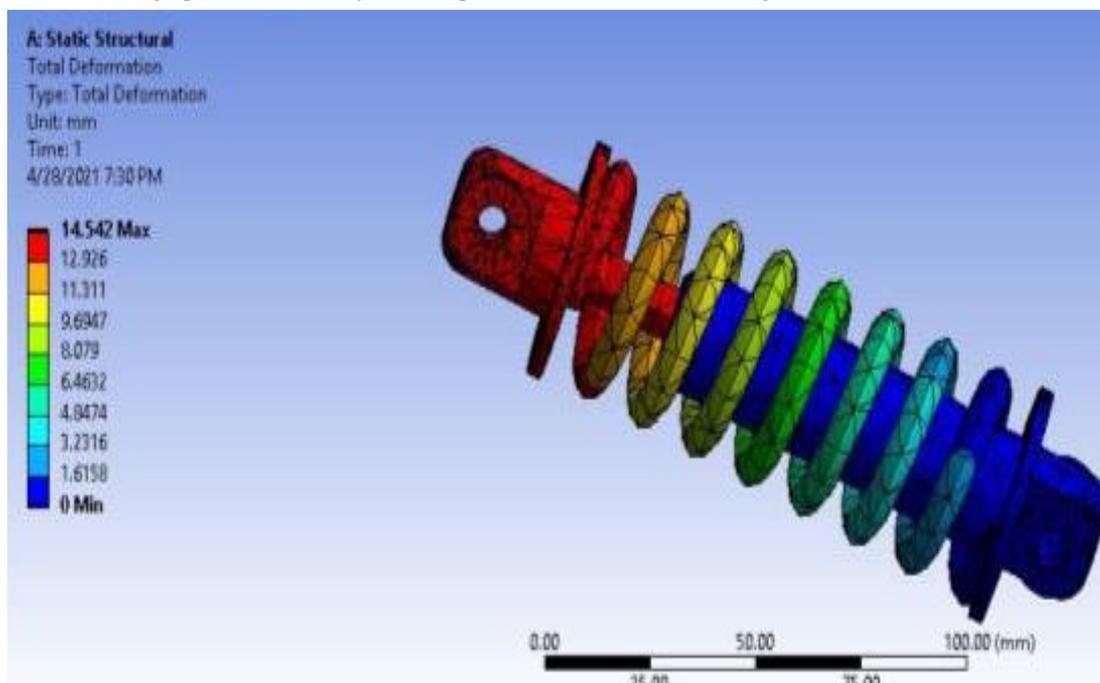


Figure 11: Total Deformation results for ASTM A227 Spring steel at 893N

Figure 11 shows the total deformation for the suspension system with material ASTM A227 Spring Steel with loading at 893N. The plot reveals that the total deformation in the system is at 14.542mm and it occurs on the top of the system whereas the bottom of the suspension system is fixed. This high deformation is seen because the results include the spring and damper effect and the deformation in the component. A large percentage of the deformation is in the spring between the values 1.61mm and 11.31mm.

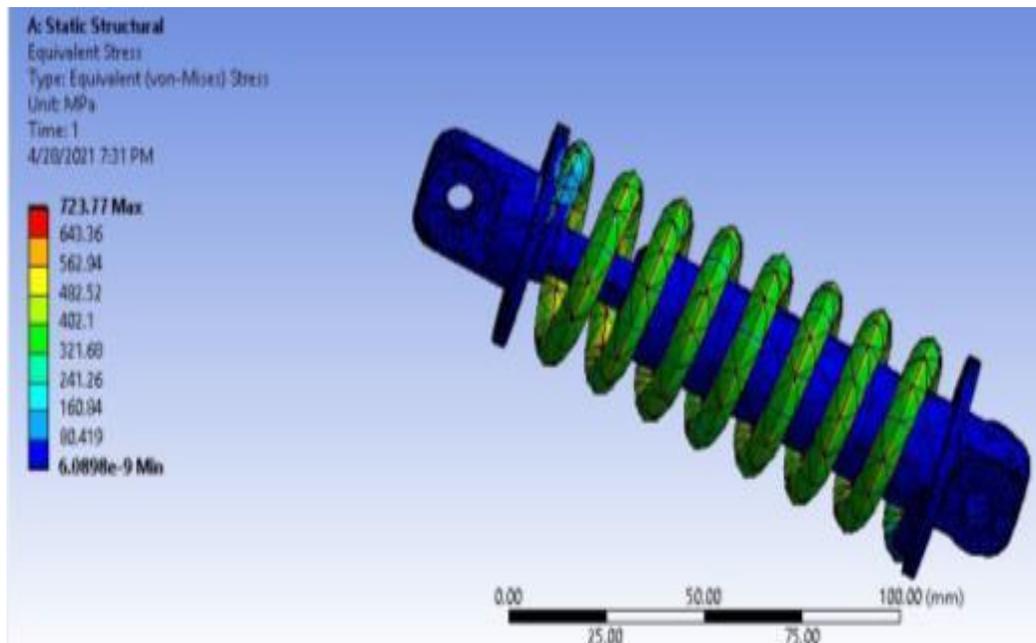


Figure 12: Von Mises Stress results for ASTM A227 Spring steel at 893N

Figure 12 gives the plot for the Von Mises stress developed in the suspension system with the material ASTM A227 Spring steel at 893N load. The results indicate that the maximum stress developed is in the springs of the system and rest of the components experience negligible forces. This is optimum because the load path for this system is through the springs and not any other components. The maximum value of stress is seen at 723.77MPa but a large portion of the system experiences stress in the range of 321.69MPa and 402.1MPa.

4. Beryllium Copper ASTM B197

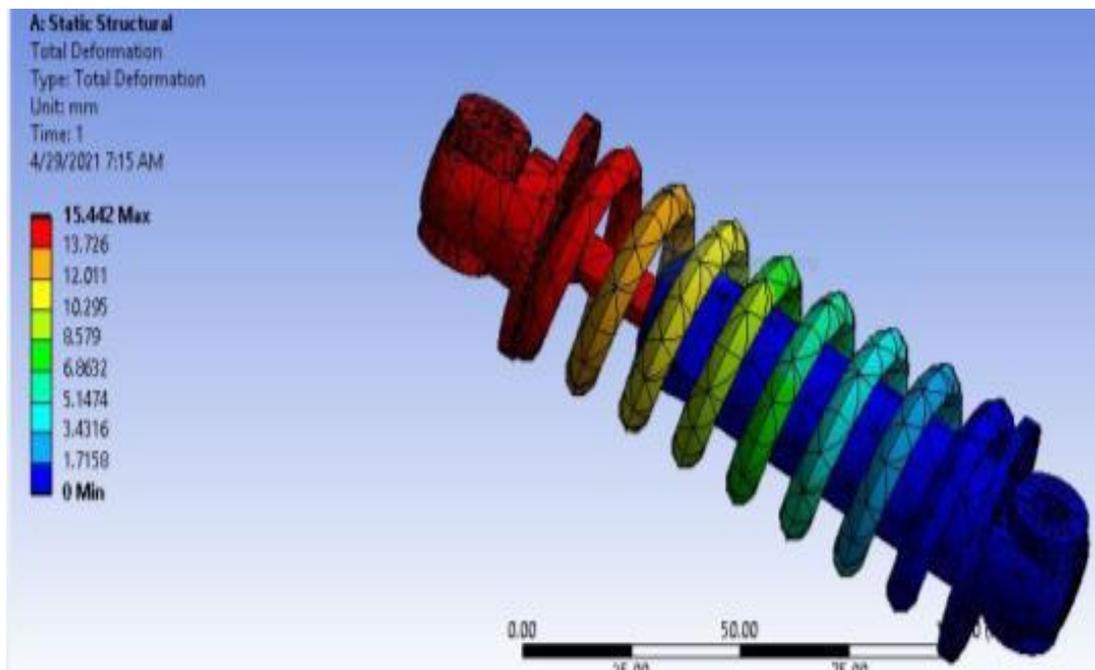


Figure 13: Total Deformation results for Beryllium Copper ASTM B197 at 654N

Figure 13 shows the total deformation for the suspension system with material Beryllium Copper ASTM B197 with loading at 654N. The plot reveals that the total deformation in the system is at 15.442mm and it occurs on the top of the system whereas the bottom of the suspension system is fixed. This high deformation is seen because the results include the spring and damper effect and the deformation in the component. A large percentage of the deformation is in the spring between the values 1.7mm and 12.011mm.

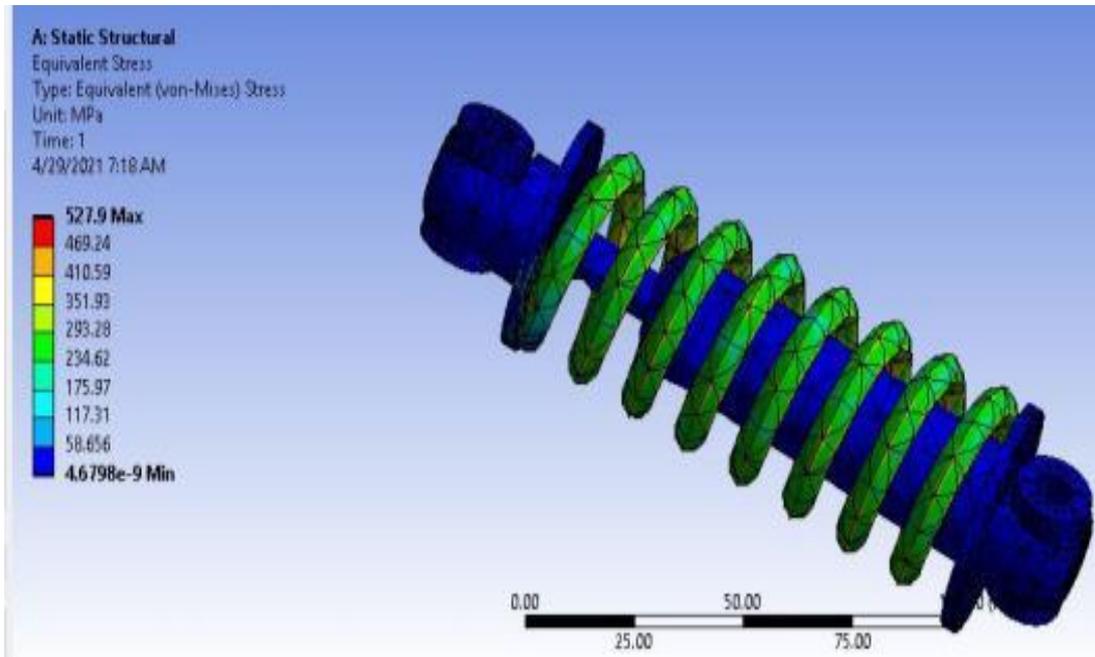


Figure 14: Von Mises Stress results for Beryllium Copper ASTM B197 at 654N

Figure 14 gives the plot for the Von Mises stress developed in the suspension system with the material Beryllium Copper ASTM B197 at 654N load. The results indicate that the maximum stress developed is in the springs of the system and rest of the components experience negligible forces. This is optimum because the load path for this system is through the springs and not any other components. The maximum value of stress is seen at 527.9MPa but a large portion of the system experiences stress in the range of 234.62MPa and 293.28MPa.

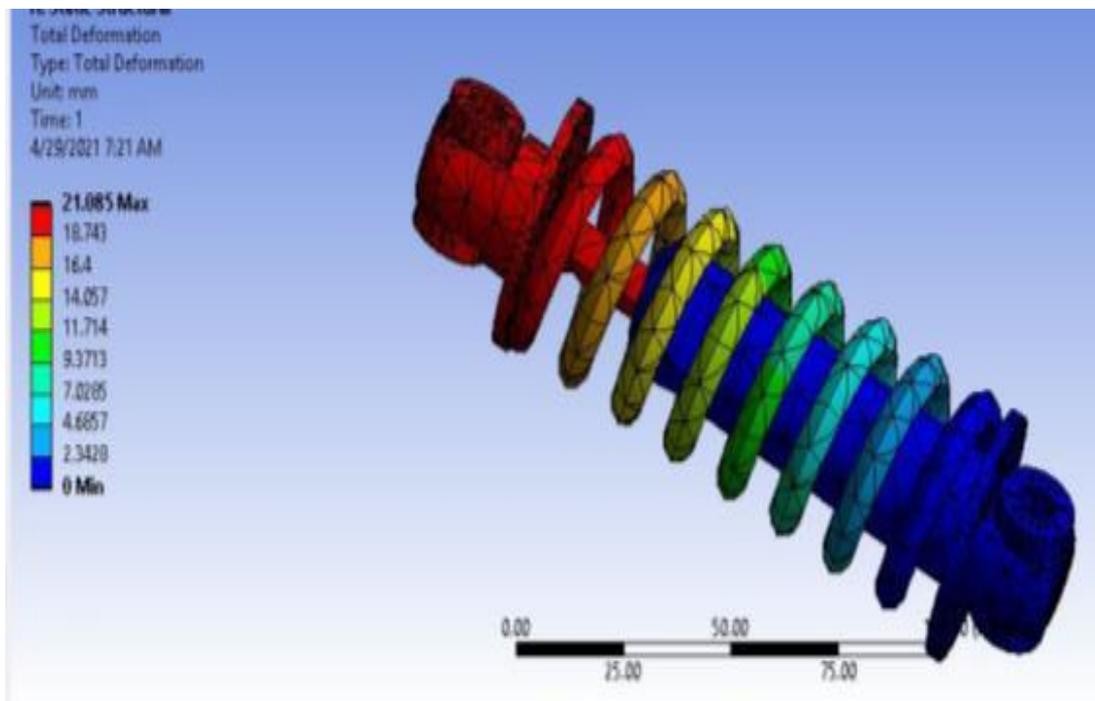


Figure 15: Total Deformation results for Beryllium Copper ASTM B197 at 893N

Figure 15 shows the total deformation for the suspension system with material Beryllium Copper ASTM B197 with loading at 893N. The plot reveals that the total deformation in the system is at 21.085mm and It occurs at the top of the system, while the suspension system's bottom is fixed. This high deformation is seen because the results include the spring and damper effect and the deformation in the component. A large percentage of the deformation is in the spring between the values 2.34mm and 16.4mm.

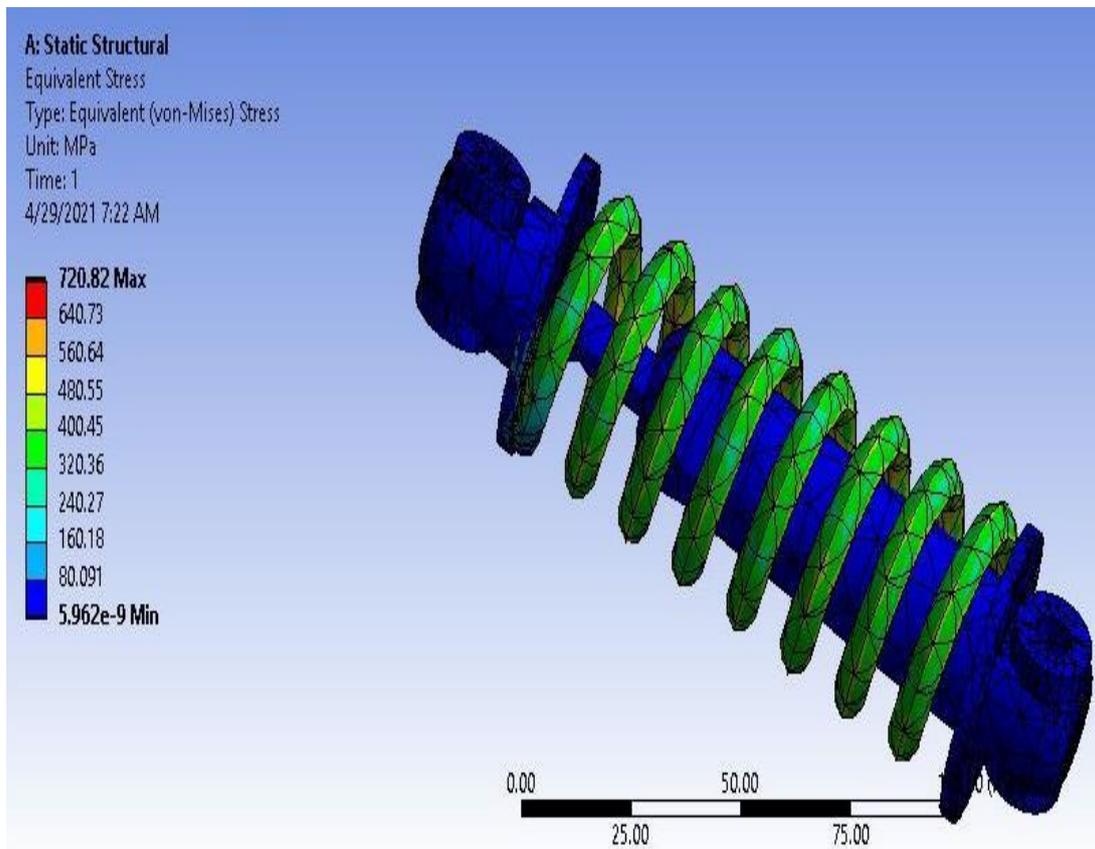


Figure 16: Von Mises Stress results for Beryllium Copper ASTM B197 at 893N

Figure 16 gives the plot for the Von Mises stress developed in the suspension system with the material Beryllium Copper ASTM B197 at 654N load. The results show that the system's springs receive the most stress, while the rest of the components are subjected to negligible forces. This is optimum because the load path for this system is through the springs and not any other components. The maximum value of stress is seen at 720.82MPa but a large portion of the system experiences stress in the range of 320.36MPa and 400.45MPa.

V. RESULTS COMPARISON

Table 1: Results comparison for the suspension system assembly

Materials	Load Applied (N)	Deformation (mm)	Von Mises Stress (MPa)
Stainless Steel AISI 302	654	10.85	530.07
	893	14.316	723.77
INCONEL 718	654	13.42	539.75
	893	18.265	735.76
ASTM227 SPRING STEEL	654	10.65	530.07
	893	14.542	723.77
BERYLLIUM COPPER ASTM B197	654	15.442	527.9
	893	21.085	720.82

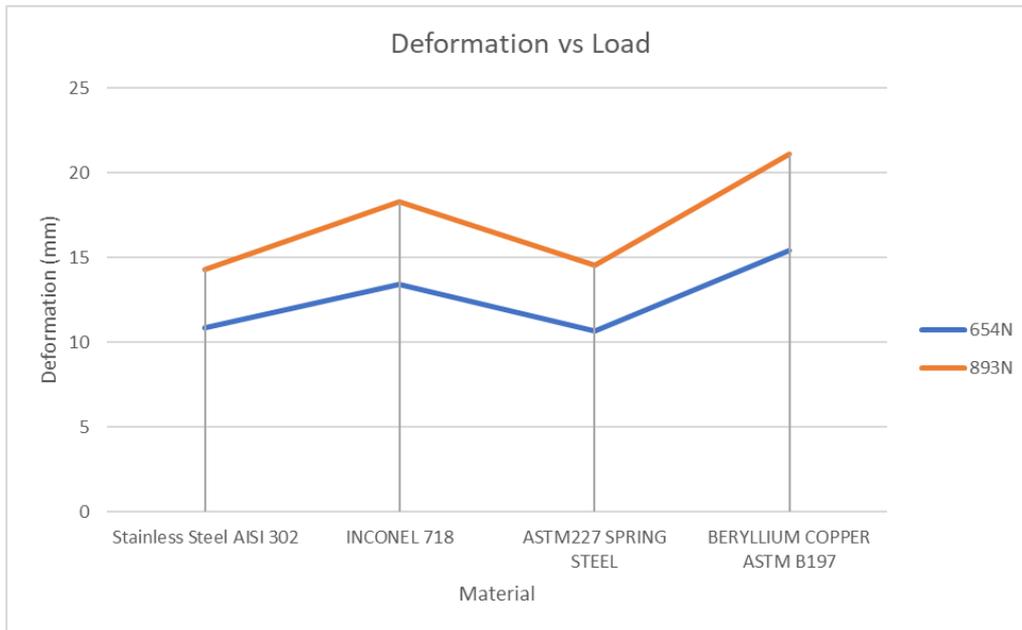


Figure 1: Total Deformation results comparison for the suspension system assembly

Figure 1 gives the comparison of deformation results for the suspension system assembly. The graph shows that the spring steel material gives the lowest deformation for both loadings and can be selected as the optimum material for the given conditions. The maximum deformation is seen with the beryllium copper and this also exceeds the yield limit of the material and hence can be considered as a failure.

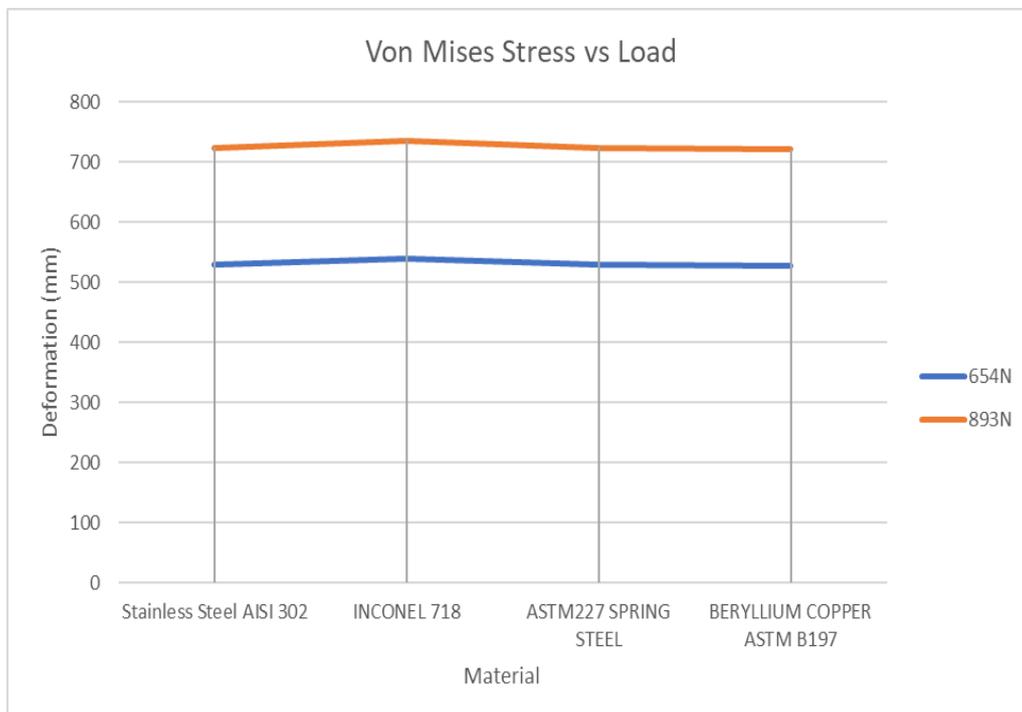


Figure 2: Von Mises stress results comparison for the suspension system assembly

Figure 2 gives the Von Mises stress results comparison for the suspension system assembly. The graph indicates that the variation in the stress values between the materials is negligible and the maximum difference is seen between AISI 302 and INCONEL 718. The lowest stress developed is seen with the beryllium copper material at 527MPa.

From the results above given in Figures 1 and 2 and table 1, the optimum material under the given conditions is ASTM227 SPRING STEEL at 654.

VI. CONCLUSION

A model of the suspension system was generated using a modeling software and was imported into a solver. The model was discretised and loads were applied to simulate a realistic situation. Initially the original model was analyzed and different materials were compared. The geometry and spring stiffness of the suspension system were changed for two scenarios each using the best material. The final results were compared and the following conclusions were drawn.

- A comparison between the AISI302, INCONEL 718, ASTM227 Spring Steel and Beryllium Copper (Existing Material) showed that the optimum material for the given conditions was found to be spring steel.
- A variation in the cylinder diameter of the suspension showed that a larger diameter cylinder in the suspension induces higher stress and is not optimal under the given conditions.
- The best combination of parameters variation between the cylinder diameter and the spring stiffness is found to be 22mm cylinder diameter and 0.15N/mm spring stiffness.

ACKNOWLEDGEMENTS

It gives me an immense pleasure to write an acknowledgement to this Project Report, a contribution of all people who helped me realize it. I take this opportunity to express our respectful regards to our beloved principal Dr. S. S. INJAGANERI for permitting us to do this Project Report.

Also I express my deep sense of gratitude and appreciation to our beloved HOD & PG Co-ordinator DR. M. S. HEBBAL for this enthusiastic inspiration and amicable in all phases of our Project Report.

With due respect I would like to express my sincere thanks to my Guide Prof. R. S. MATTI for their struggling effort and timely guidance, patience in solving our doubts, which kept cropping up in due course of my Project Report work needs special credits.

My sincere thanks to all those people who have contributed to this seminar in every of this like My Parents , Mechanical Staff, and My Friends.

VII. REFERENCES

- [1] Suda, Yoshihiro, Shigeyuki Nakadai and Kimihiko Nakano. "Hybrid suspension system with skyhook control and energy regeneration (development of self-powered active suspension)." *Vehicle system dynamics* 29, no. S1 (1998): pp. 619-634
- [2] Martins, Ism nio, M Esteves, F Pina Da Silva and Pedro Verdelho. "Electromagnetic hybrid active-passive vehicle suspension system." In *Vehicular Technology Conference, 1999 IEEE 49th*, vol. 3, pp. 2273-2277. IEEE, 1999
- [3] Cairano, S Di, Alberto Bemporad, Ilya V Kolmanovsky and Davor Hrovat "Model predictive control of magnetically actuated mass spring dampers for automotive applications." *International Journal of Control* 80, no. 11 (2007): 1701-1716
- [4] Li Zhongjie, Lei Zuo, George Luhrs, Liangjun Lin and Yi-xian Qin "Electromagnetic energy harvesting shock absorbers: design, modeling, and road tests." *IEEE Transactions on Vehicular Technology* 62, no. 3 (2013): 1065-1074
- [5] Yao G Z, F F Yap, G Chen, W H Li and S H Yeo "MR damper and its application for semiactive control of vehicle suspension system." *Mechatronics* 12, no 7 (2002): 963-973
- [6] Rashid M M, M A Hussain, N Abd Rahim and J S Momoh. "Development of a semi-active car suspension control system using magneto-rheological damper model." *International Journal of Mechanical and Materials Engineering* 2, no. 2 (2007): 93-108
- [7] Shaojun Liu "An Active Suspension System Operated by High Speed Solenoid Valves and Its Control." *Automotive Engineering* 18, no. 4 (1996)
- [8] Bing, Wang, Han Bingyuan, Wang Yan and Ai Xifeng "Research Review of Automobile Magneto-rheological Damper [J]" *Forest Engineering* 4 (2008): 012
- [9] Ebrahimi, Babak, Mir Behrad Khamesee and Farid Golnaraghi "Eddy current damper feasibility in automobile suspension: modelling, simulation and testing." *Smart Materials and Structures* 18, no. 1 (2008): 015017.