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Design and Material Analysis of a Suspension System in Scooter by using Finite Element Analysis Method

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ABSTRACT

The principle part for a vehicle suspension is the compression spring system, which is fabricated for arresting shock impulse. Suspension system work on the principle of fluid transformation between compression and expansion cycle. Mostly the suspension system is used in motorcycles for providing better handling, prompt braking, safety, and comfort by keeping the passengers isolated from road noise, bumps, and vibration. 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 the substantially reduced amplitude of disturbances. In most of the cases, the spring which is used in the scooter suspension system is made up of beryllium copper, phosphor bronze and titanium, but in this research paper a scooter suspension system is designed and the designed suspension system is analyzed using ansys with different material properties. The composite material gives less deformation because of the high stiffness to load carrying capacity. So the Composite suspension system is recommended for two and three-wheeled vehicles.

Keywords: Suspension system, C40, C70 steel, Al-SiC composites, Static structural analysis, Helical Spring.

1. INTRODUCTION

In order to prevent the accident and to safeguard the occupants from accident, horn system is necessary to be analysed in the context of the maximum safe load of a helical compression spring. In this analysis, the helical spring is designed and the designed spring is analysed using NASTRAN by applying stainless steel as a spring material. In this analysis, the load is increased slightly and the maximum shear stress is calculated at each case [1]. In this paper the author designed a spring suspension system using solid works and the taken three different material in the steel family, the load of 850N is applied in the compressive state and the von-mises stress and total deformation are calculated at each material conditions and the values from the analysis is compared with the theoretical value and the alloy steel has maximum load carrying capacity in both theoretical and analysis method [2]. The spring suspension system of a three-wheeled vehicle is designed and the material analysis is done using ansys workbench, the material is taken as SP ST GRDII and the new designed is developed by changing the helix angle and number of turns, the result will conclude that the new design will perform better than the existing design from the result the author had concluded that the new design will have an 11% increase on load carrying capacity [3]. In this paper, the 3D model of the 150cc engine suspension system is designed and by changing the thickness of the spring. Structural analysis and modal analysis are done on the suspension system 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 a number of modes. Comparison is done for two materials and the author had finally concluded that steel spring had lesser deformation and minimum von-mises stress so the steel spring is taken for manufacturing of spring suspension system [4]. The three-wheeler suspension system is analysed in this paper, as this spring is used in the TWV's front suspension it is necessary to find out the load acting on the spring in actual practice in static condition as well as in dynamic condition. Normally the total weight of the vehicle with driver and one passenger is about 405 Kg, but for the safer side, it is taken as 500 Kg concentrated at the center of gravity of the vehicle. It is assumed that this total weight is equally divided into two springs of rear suspension and one spring of front suspension. The elastic behavior and the stress analysis of springs employed in the TWV's front automotive suspension have been presented and discussed in this paper. The stress distribution clearly shows that the shear stress is having a maximum value at the inner side of every coil. The distribution of the stress is similar in every coil. So the probability of failure of spring in every coil is same except end turns [5]. The feasibility of adopting composite material for the design of helical coil suspension system. In this project, the design analysis of a combination of steel and composite material will be performed. This will result in greater stiffness with the reduced weight of the spring which will be the prime advantage and the steel spring will have lesser deformation when compared with other material [6].

As per the literature survey, most of the author has done the material analysis in the suspension system by taking steel as the material, in this paper the current analysis is fully focused on the composite material. In this, the 125cc scooter suspension system is designed and it is taken for static analysis of taken C40 steel, C70 steel, and Al-SiC as a material and the output parameter such as total deformation and von-mises stress are calculated using ansys.

2. MODELLING OF SPRING SUSPENSION SYSTEM

Solid works mechanical design automation software is a feature-based, parametric solid modeling design tool which advantage of the easy to learn windows graphical user interface. We can create fully associate 3-D solid models with or without while utilizing automatic or user-defined relations to capture design intent. The 3 Dimension model of the suspension system is designed using solid works in 2016. Figure 1 represents the assembly of the spring suspension system of a 125cc scooter.

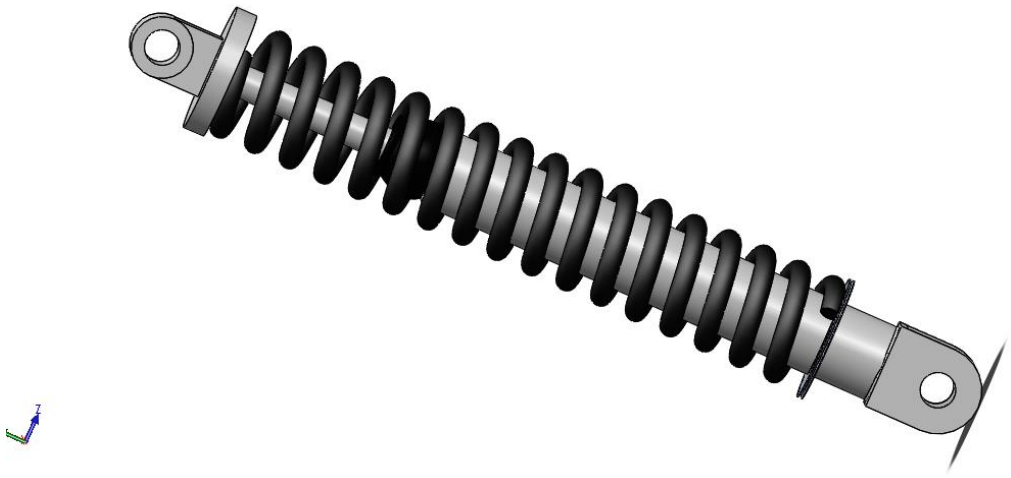

Fig 1. Suspension System

2.1 Material Properties of the Suspension System

The designed file is converted into IGES/STEP format to import in ansys workbench. The analysis of the suspension system is done using ansys workbench 18.1 and the analysis is chosen as static structural analysis and in this analysis, three different materials are taken to do the static analysis. The three materials taken are C40 steel, C70 steel, and Al-SiC. The table.1 will give the material property of the above materials

Table 1. Material Property

Parameter	C40 Steel	C70 Steel	Al-SiC Composites
Density Kg/m^3	7350	7670	7850
Young's Modulus Mpa	99974	198000	205000
Poisson's Ratio	0.292	0.33	0.3
Compressive Yield Strength Mpa	82	105	230
Compressive Ultimate Strength Mpa	210	296	550

3. ANALYSIS USING ANSYS WORKBENCH

In the ansys workbench 18.1, the structural analysis is done of the designed spring suspension system. In this analysis, the bottom end of the suspension system is fixed and a load of 1000N is acted from the upward side (i.e) Y-Axis. The output parameter such as Total deformation and Equivalent elastic stress and Equivalent strain are taken in each condition. The analysis is done by changing the materials in the material library and the results are compared. Figure 2 & 3 will represent the mesh model and the boundary condition applied to the suspension system in ansys workbench 18.1

3.1 Simulation Procedure

In this study to analysis the stresses, we have followed these steps:

1. Creation of a 3-D model of the Suspension system. This job has been done using solid works 2016 software. The main model of suspension system has been created and imported in Ansys in STEP format.
2. Mesh generation is the next step in structural analysis. Many kinds of mesh have been generated and finally, after grid independency investigation, the perfect mesh was selected and applied to the model.
3. Calculation/Apply the boundary conditions for the design model.
4. Using the ansys solver, solve the conditions to obtain the analysis results.
5. Visualization and study of the results are done with the Postprocessor.
6. Comparison of the results of the suspension system with the different material property.
7. Compare the results and recommendation some suggestions to improve the performance of the life and performance of the suspension system.

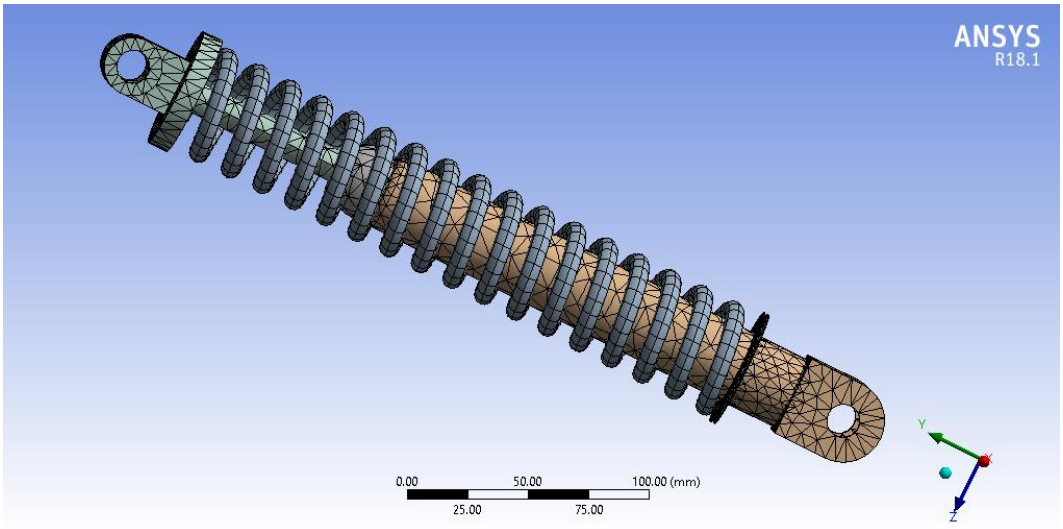

Fig 2. Mesh Generated in Ansys Workbench

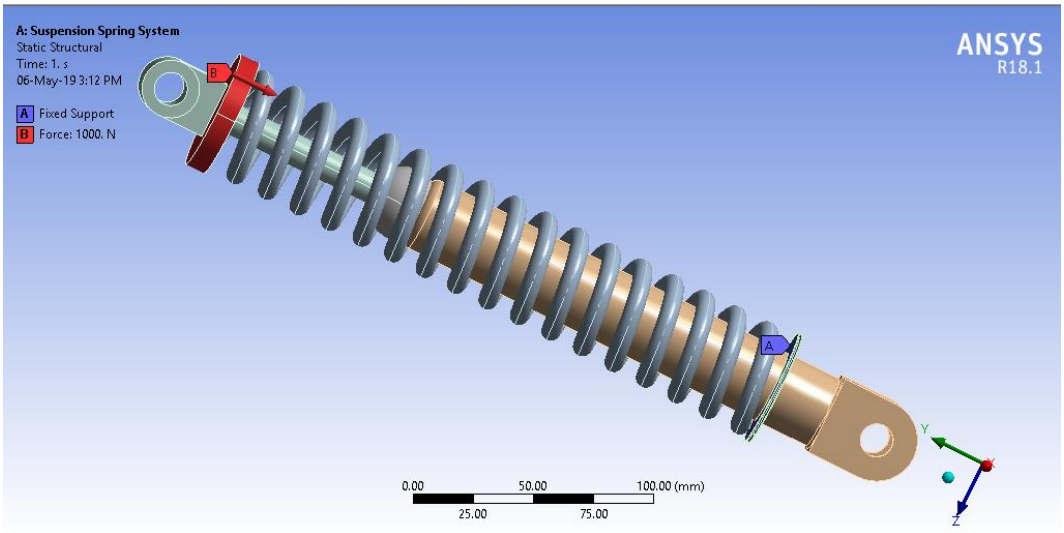

Fig 3. Boundary Condition applied for the model

4. STATIC STRUCTURAL ANALYSIS

In order to perform static structural analysis, the STEP file is imported in the workspace and then it is taken to generate mesh, to get the mesh of the model the fine structure is selected and the boundary conditions are applied to the model and then the required solution is taken as per the output data needed.

4.1 C40 Steel

In this analysis, the mesh is generated for the model to do the static structural analysis. In order to perform the analysis the lower end of the suspension system is fixed by the support and the compressive load of 1000N is applied normal to the surface of the spring system, in order to do analysis the material property of C40 steel is chosen as a material for the suspension system and the solution such as total deformation and von-mises stress are taken for the model. The figure 4-7 will represent the output solution which is taken from ansys workbench 18.1

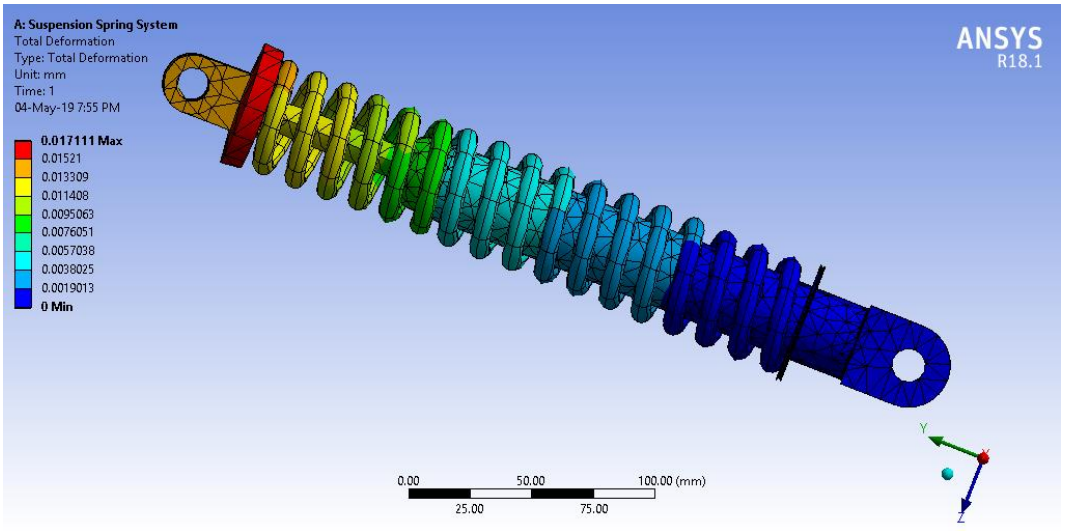

Fig 4. Total Deformation of C40 Steel Suspension System

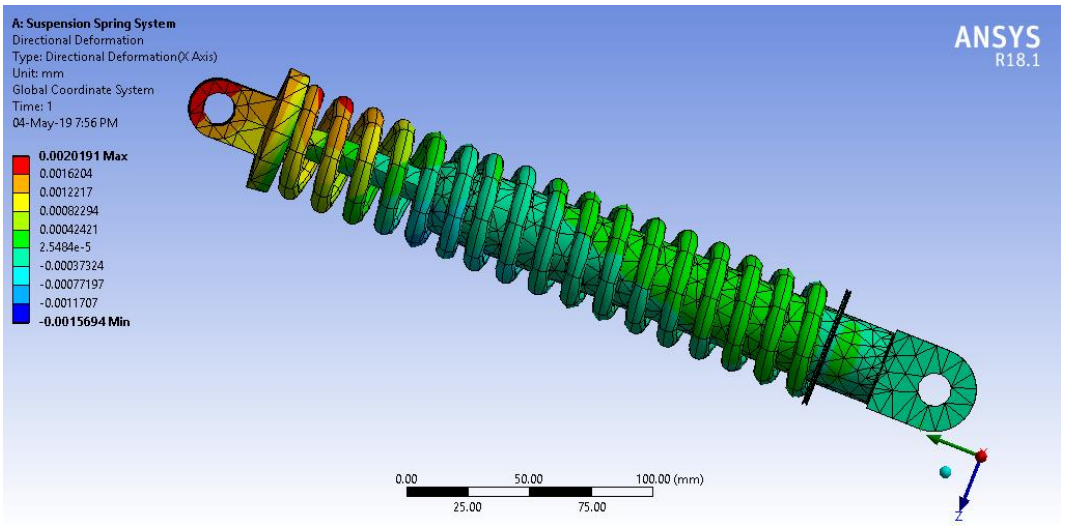

Fig 5. Directional Deformation of C40 Steel Suspension System

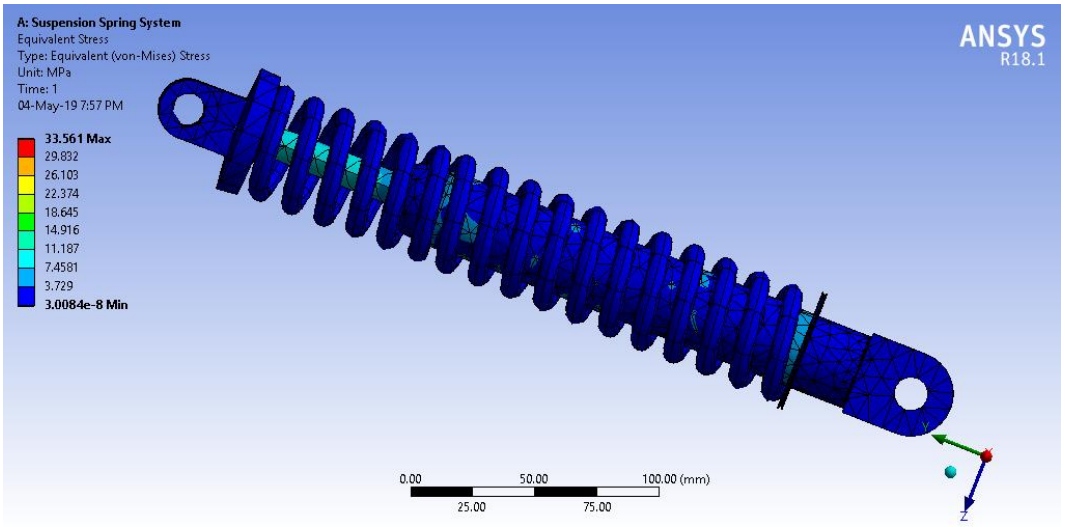

Fig 6. Von-mises Stress of C40 Steel Suspension System

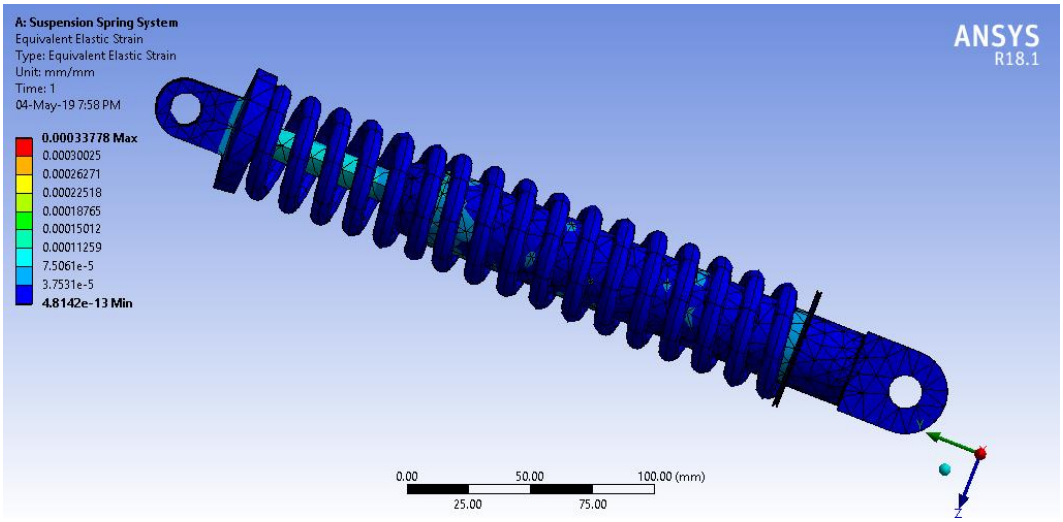

Fig 7. Equivalent Strain of C40 Steel Suspension System

4.2 C70 Steel

In this analysis, the mesh is generated for the model to do the static structural analysis. In order to perform the analysis the lower end of the suspension system is fixed by the support and the compressive load of 1000N is applied normal to the surface of the spring system, in order to do analysis the material property of C70 steel is chosen as a material for the suspension system and the solution such as total deformation and von-mises stress are taken for the model. The figure 8-11 will represent the output solution which is taken from ansys workbench 18.1

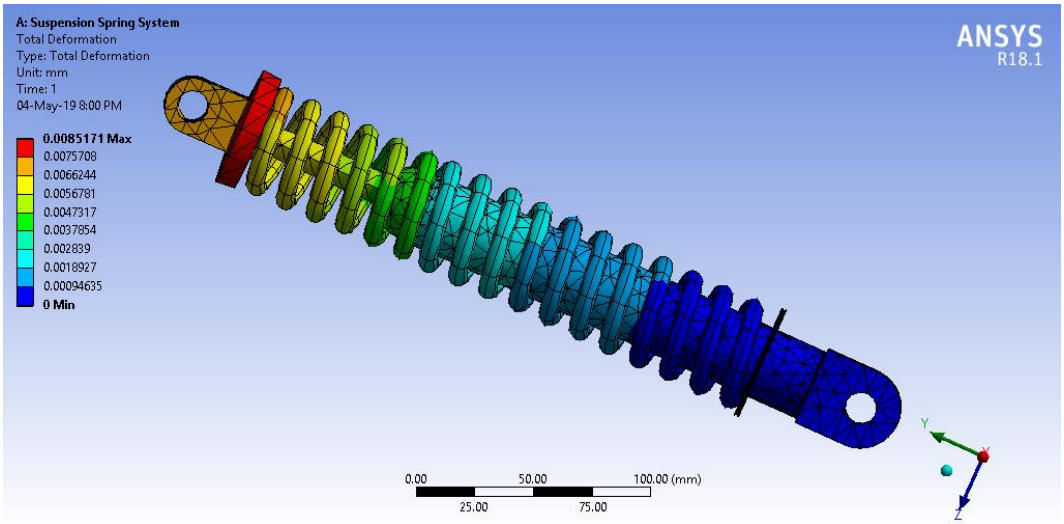

Fig 8. Total Deformation of C70 Steel Suspension System

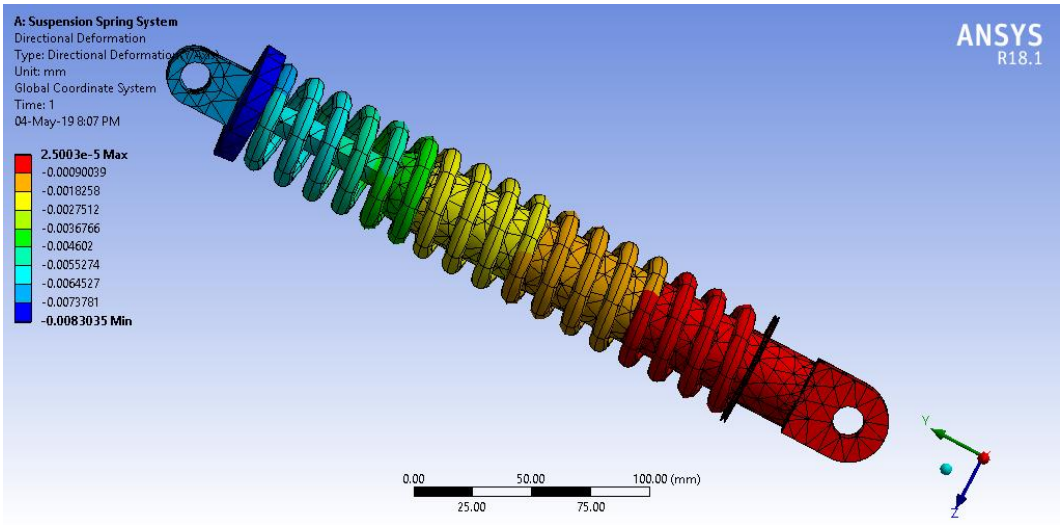

Fig 9. Directional Deformation of C70 Steel Suspension System

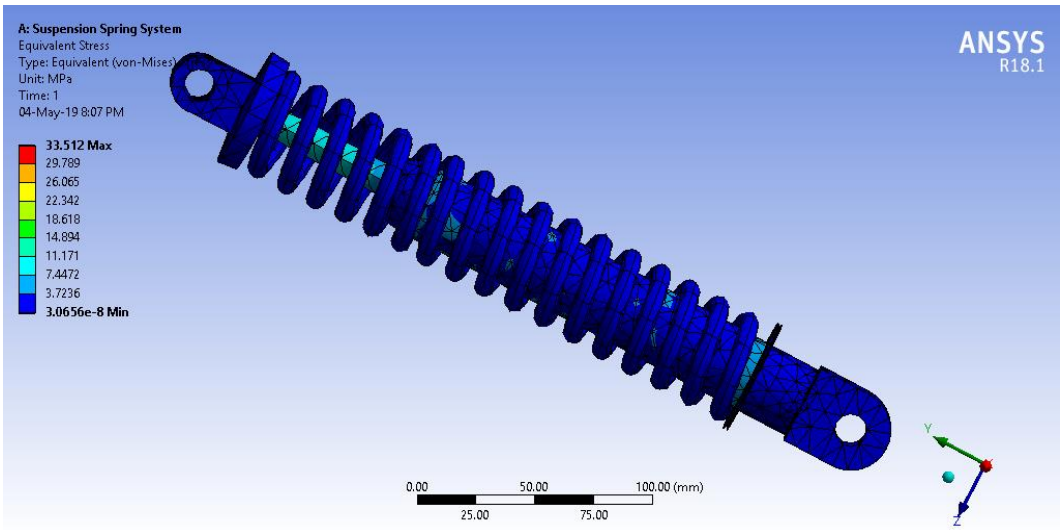

Fig 10. Von-Mises Stress of C70 Steel Suspension System

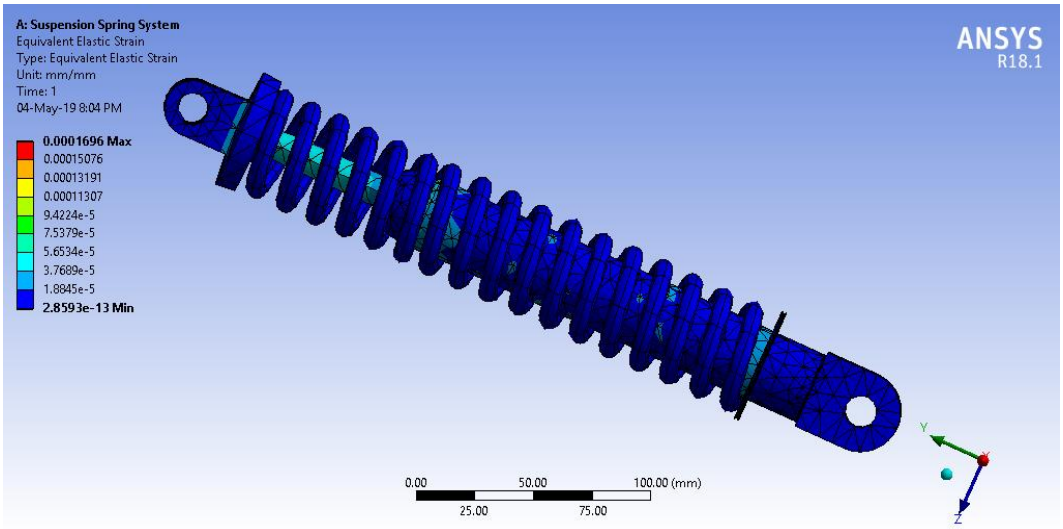

Fig 11. Equivalent Strain of C70 Steel Suspension System

4.3 Al-SiC Composites

In this analysis, the mesh is generated for the model to do the static structural analysis. In order to perform the analysis the lower end of the suspension system is fixed by the support and the compressive load of 1000N is applied normal to the surface of the spring system, in order to do analysis the material property of Al-SiC is chosen as a material for the suspension system and the solution such as total deformation and von-mises stress are taken for the model. The figure 12-15 will represent the output solution which is taken from ansys workbench 18.1

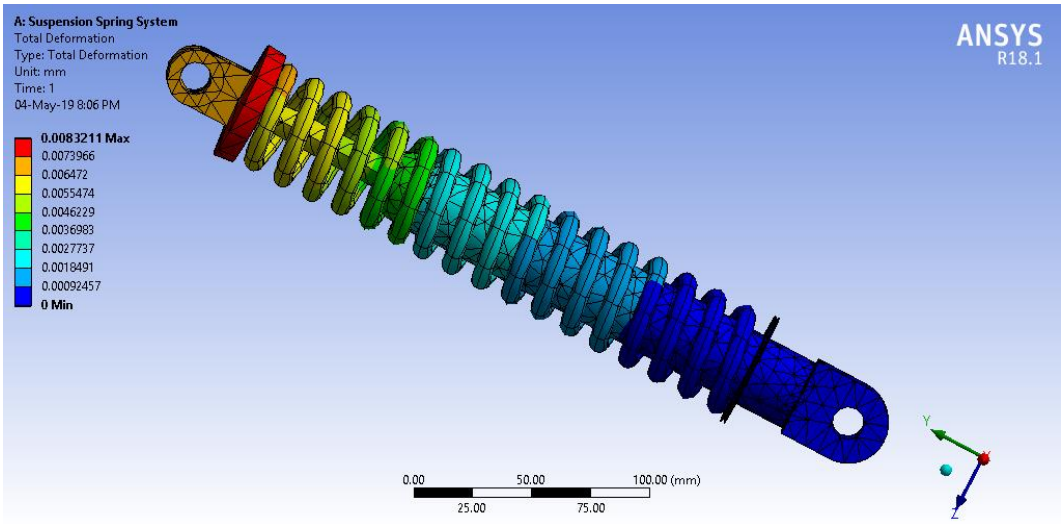

Fig 12. Total Deformation of Al-SiC Composites Suspension System

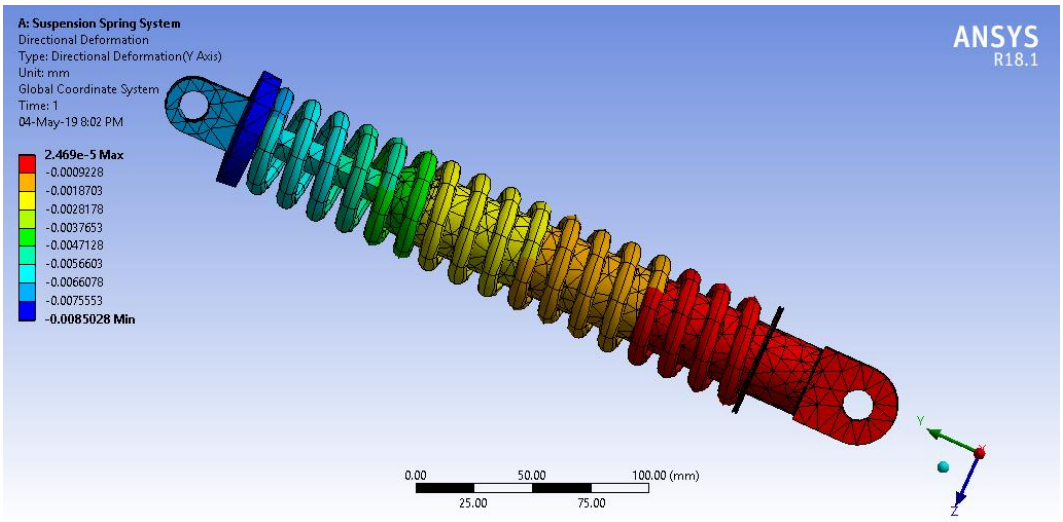

Fig 13. Directional Deformation of Al-SiC Composites Suspension System

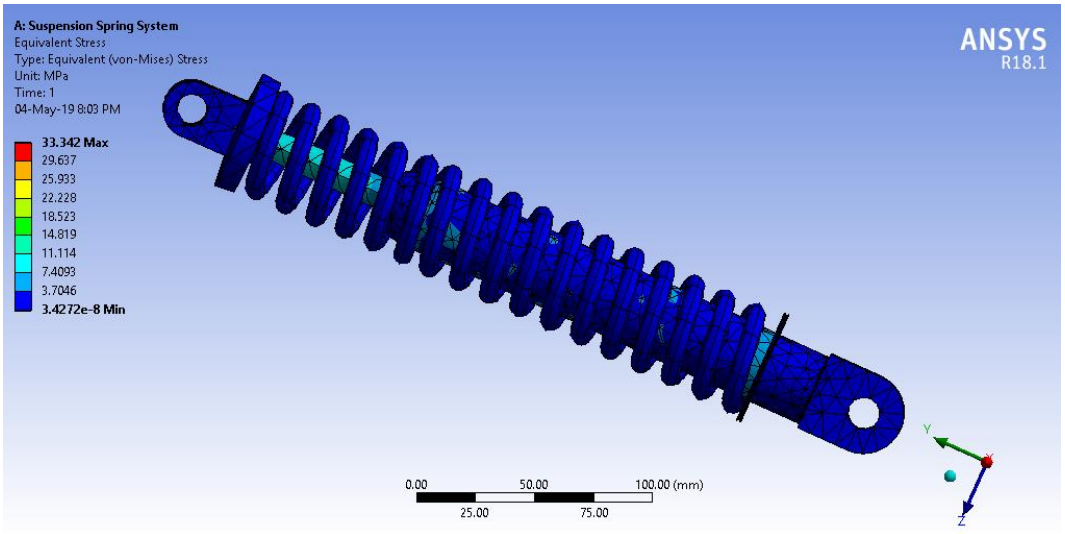

Fig 14. Von-mises Stress of Al-SiC Composites Suspension System

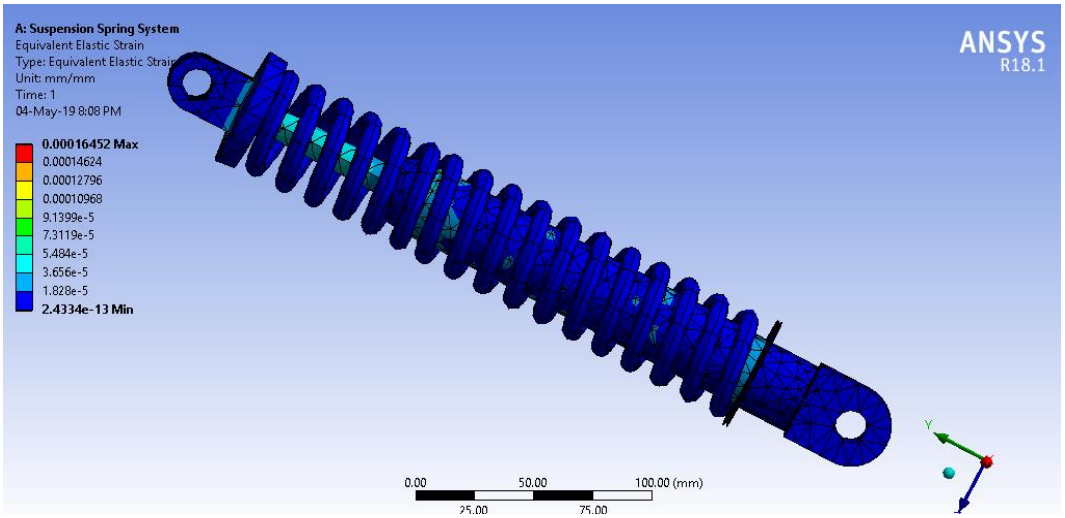

Fig 15. Equivalent Strain of Al-SiC Composites Suspension System

5. RESULTS AND DISCUSSION

The helical spring is the important moving part in a suspension system, the load changes during the vehicle running are balanced by the suspension system, and the sudden vibration produced by the scooter is arrested by using a suspension system since it acts as a damping device in the vehicle.

The analysis of the suspension system is done using Ansys workbench 18.1 and the material used in the suspension system is altered in each analysis and the values at each case are found. Table 2 represents the output results which are taken from static structural analysis. The figure 16-19 represents the comparison of results at each material case.

Table 2. Result from Ansys Workbench 18.1

Parameter	C40 Steel	C70 Steel	Al-SiC Composites
Total Deformation	0.017111 mm	0.0085171 mm	0.0083211 mm
Directional Deformation (Y-axis)	0.0020191 mm	0.000025003 mm	0.00002469 mm
Equivalent Elastic Strain	0.00033778	0.00016960	0.00016452
Equivalent Stress	33.561 Mpa	33.512 Mpa	33.342 Mpa

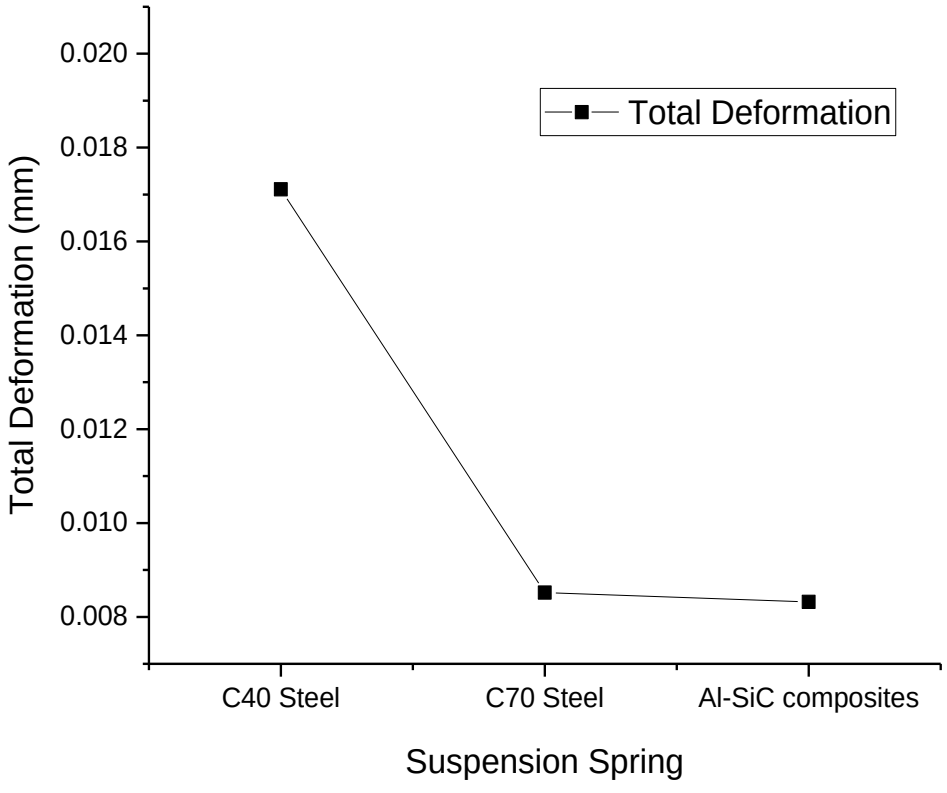

Fig 16. Total Deformation of the Suspension System

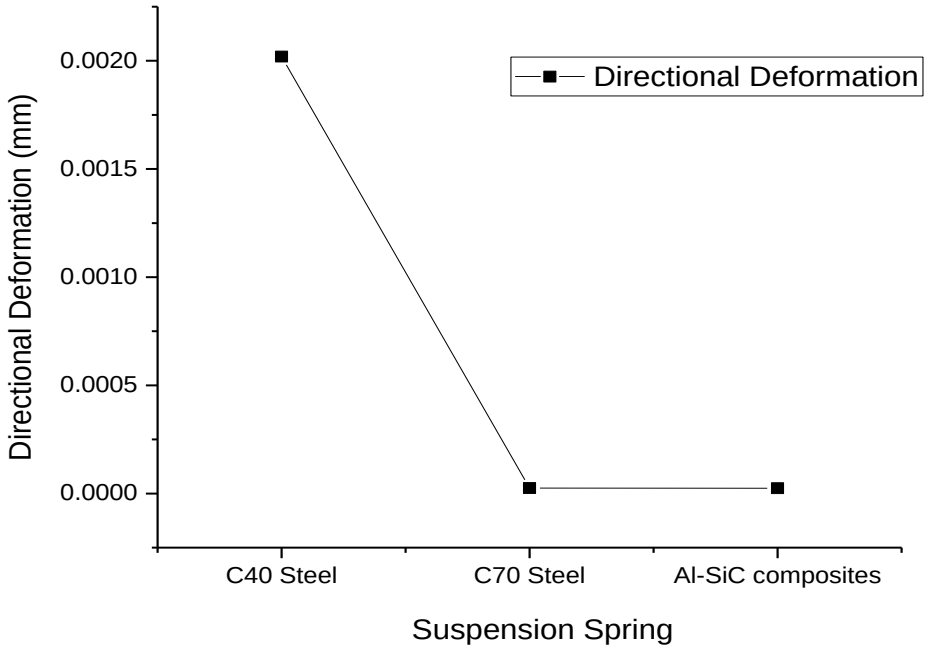

Fig 17. Directional Deformation of the Suspension System

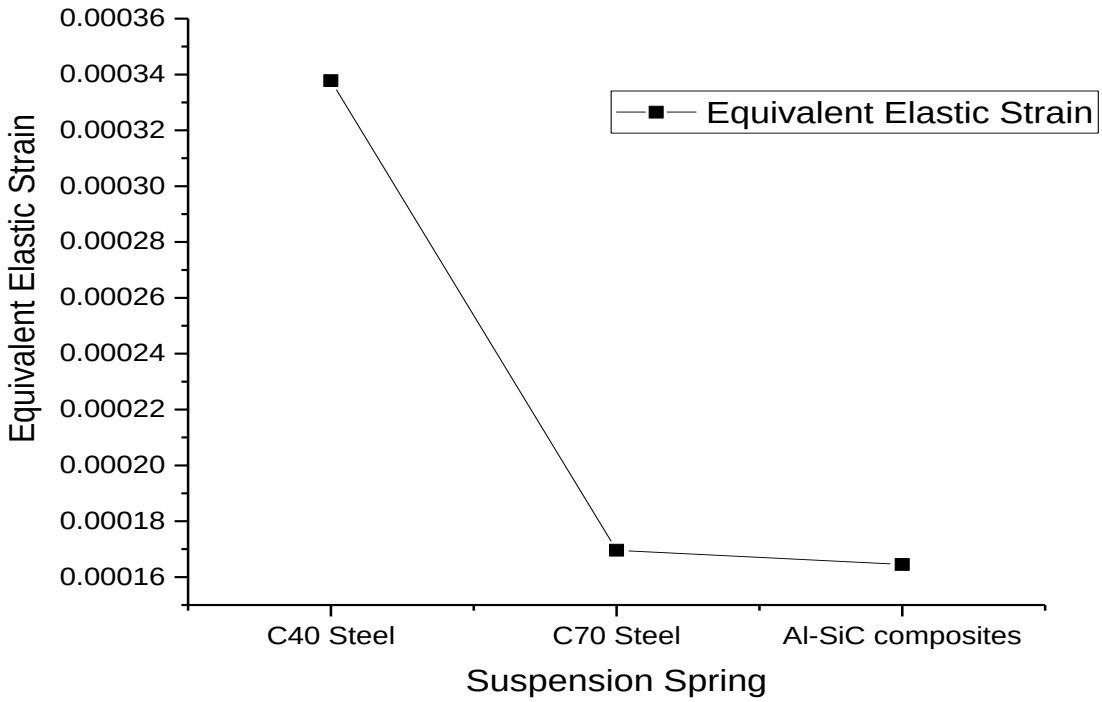

Fig 18. Equivalent Elastic strain of the Suspension System

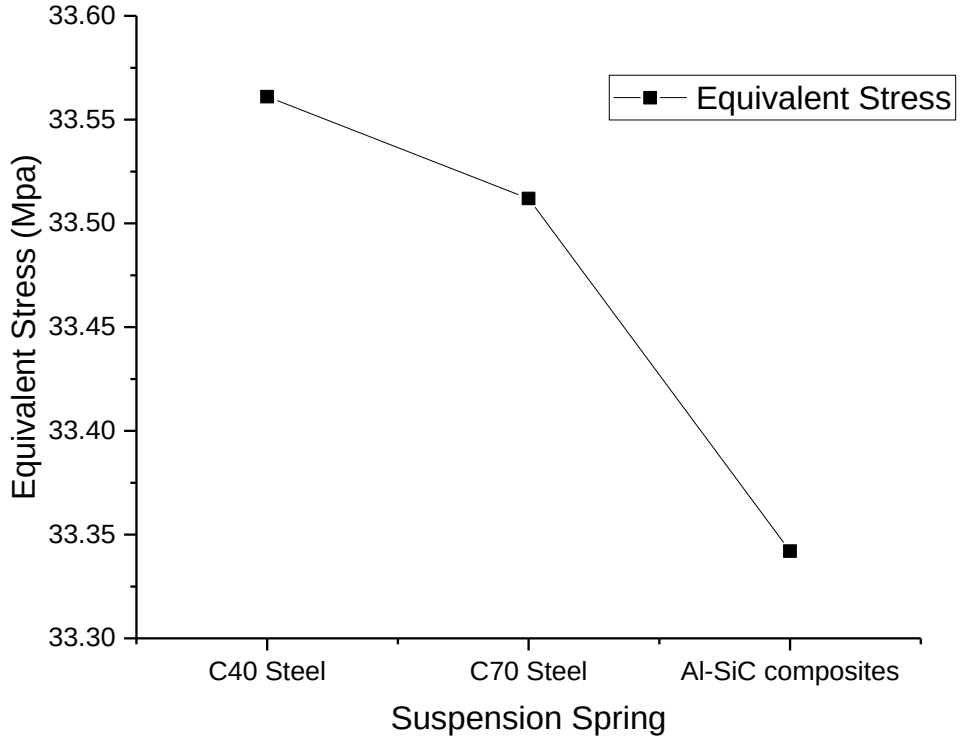

Fig 19. Von-Mises stress of the Suspension System

From the above figure 16-19 it is clearly understood that the load carrying capacity is more in Al-SiC (m-3) than C40 & C70 steel (m1 & m2). Because the yield compression value and ultimate compression is more in Al-SiC than other materials. The composite material has high stiffness to load ratio in naturally since the composite material can be used to withstand load and vibration in the suspension system.

The increase in the ultimate compression strength of the material helps the material to withstand the applied forces and to endure the stresses induced in them, so the material to be chosen should have high corrosion resisting properties. The preparation of Al-SiC composite is done by giving an external compressive pressure since it makes the grains to closely pack. The small grains size will make to high bonding which has more strength to carry the load. So the Al-SiC composite has lesser deformation when compared with other materials.

6. CONCLUSION

1. In this project, we have successfully designed a suspension system used in a 150cc bike by using 3D parametric software SolidWorks.
2. To validate the strength of our design, we have done structural analysis on the suspension system. We have done analysis by varying material such as C40 Steel, C70 Steel, and Al-SiC composite material.
3. By observing the analysis results, the analyzed stress values are less than their respective permissible limits. So our design is safe.
4. By comparing the results for all three materials, the stress value is less for Al-SiC composite than C40 & C70 Steel.

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Conflict of Interest

None of the authors have any conflicts of interest to declare.