Design and Analysis of Independent Wheel Vehicle Suspension System

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Abstract:

Independent wheel suspension system is used nowadays in almost all new modern cars. In conventional system which uses dependent suspension is not of much use as it creates more jerk in car body. Normally, when any bump or hindrance comes across vehicle, suspension system reduces the disturbance in the car. Dependent system is connected with chassis and car body frame. So with any jerk, the car body faces the disturbance. In Independent wheel vehicle suspension, the spring is connected with the wheel, which absorbs all shock and does not allow any jerk in car body.

Thesis covered brief literature review on analysis of independent suspension system. First studied existing suspension design as per standard design procedure then identifying design issue in existing design by using mechanism calculation. By using CAD tool like Solid work for critical component of independent suspension for analysis purpose and according to result for conclusion.

Keywords: Independent suspension system, Car body, Design, Analysis, CAD.

1. Introduction

Suspension system is an assembly of springs, shock absorbers and linkages that connects a vehicle to its wheels. In a running vehicle, it is the suspension system that keeps the occupants comfortable and isolated from road noise, bumps, and vibrations. Suspension system also provides the vehicle excellent handling capabilities, allowing the driver to maintain control of the vehicle over rough terrain or in case of sudden stops. Additionally, the suspension system prevents the vehicle from damage and wearing.

The basic components of the suspension system include springs, shock absorbers, kinetic parts, and auxiliary devices. The springs absorb impacts and provide cushioning when a wheel hits a bump in the road. The springs also resist the wheel's movement and rebounds, pushing the wheel back down. The type, number, and location of the springs differ based on different type of suspension systems, which will be demonstrated in the next section. The shock absorbers (dampers) restrain the spring motions and prevent the spring from continuing vibrating. In a suspension system, one shock absorber is located at each wheel.

2. Design and CAD Modelling of Independent Suspension System

As shown in Fig.1 to 4, there are different orientations of Macpherson Strut Suspension as isometric view, front view, top view and side view.

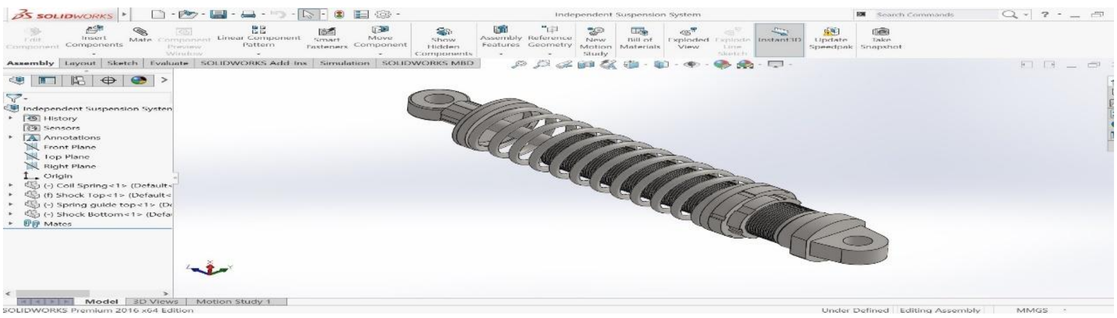

Fig.1 Isometric view of Macpherson Strut Suspension

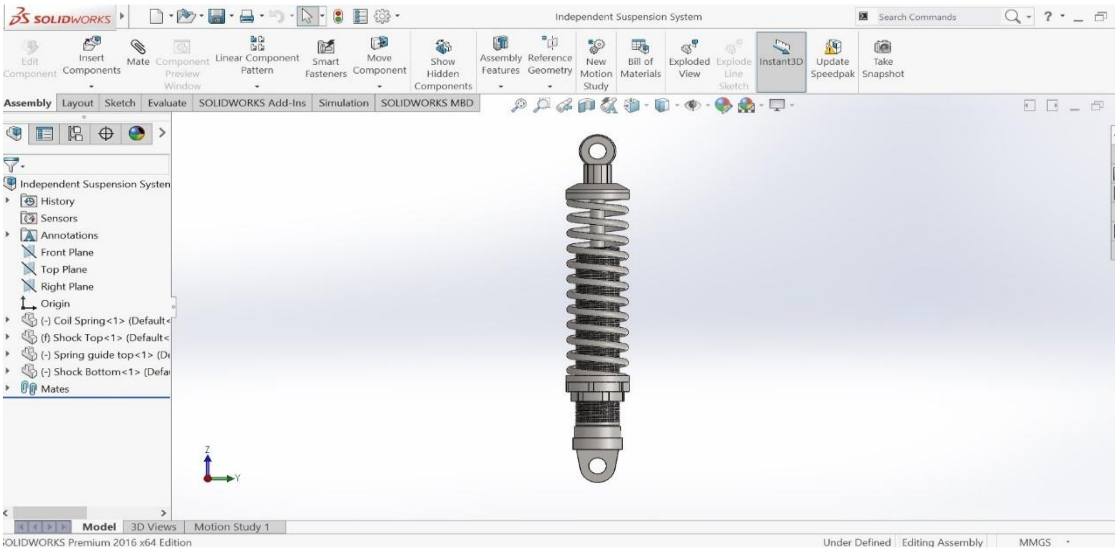

Fig.2 Front view of Macpherson Strut Suspension

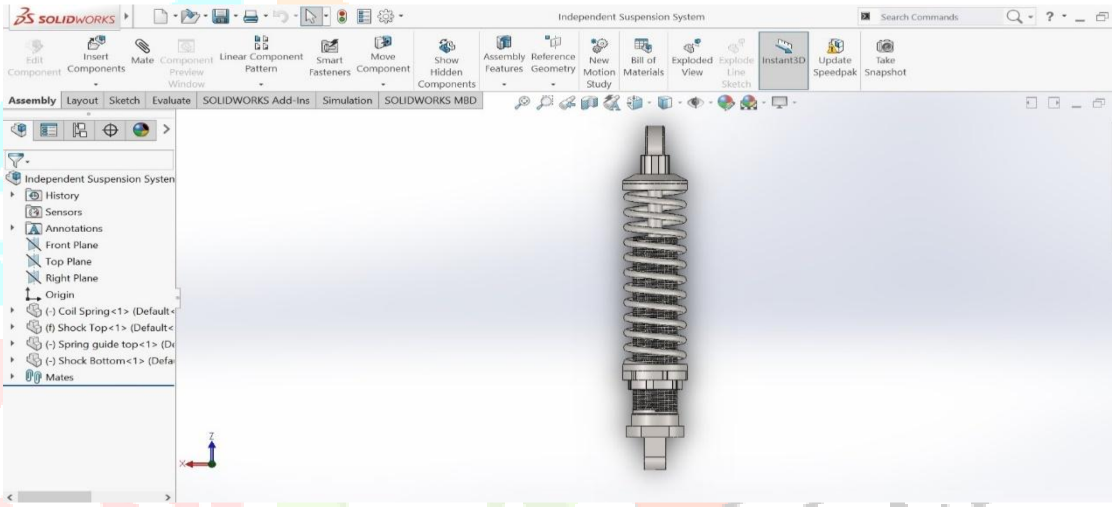

Fig.3 Side view of Macpherson Strut Suspension

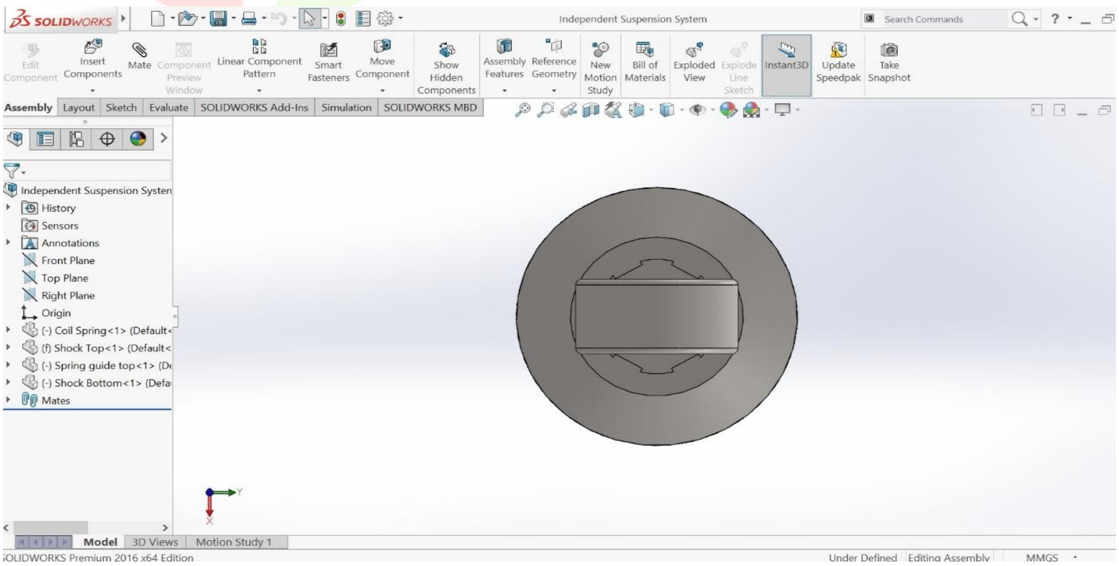

Fig.4 Top view of Macpherson Strut Suspension

3. Finite Element Analysis (FEA)

Step-1 Pre-processing

1)First Prepare Parts in Solidworks 2016.

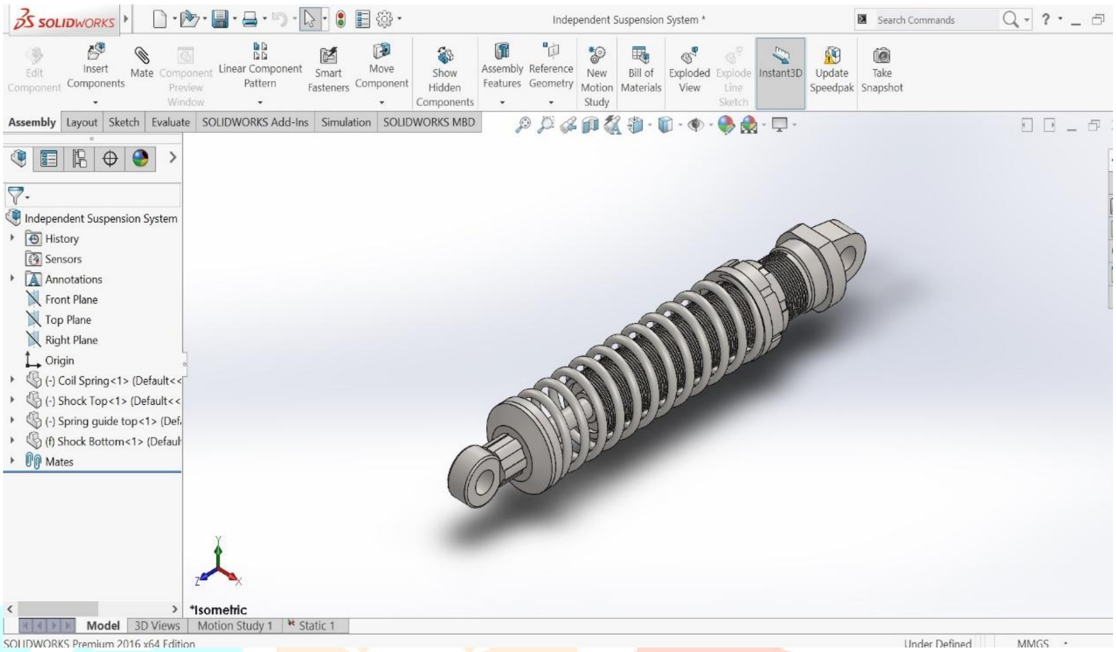

Fig. 5 Geometry of Macpherson Strut Suspensionusing static analysis

The starting point to analysis with SOLIDWORKS Simulationis a SOLIDWORKSmodel. Geometry of the model needs to be meshable into a correct finite elementmesh. This requirement of mesh-ability has very important implications. We need toensure that the CAD geometry will indeed mesh and that the produced mesh willprovide the data of interest (e.g. stresses, displacements or temperature distribution)with acceptable accuracy.

2) Check the Geometry for Meshing.

It is important to mention that we do not always simplify the CAD modelwith the sole objective of making it meshable. Often we must simplify a model eventhough it would mesh correctly “as is”, because the resulting mesh would be large (interms of the number of elements) and consequently, the meshing and the analysiswould take too long. Geometry modifications allow for a simpler mesh and shortermeshing and computing times.

1) Apply Material for Each Component

Table 1Spring Coil Material Properties (Spring Steel)

Mass Density	7700 kg/m^3
Tensile Strength	723 MPa
Yield Strength	620 MPa
Modulus of Elasticity (E)	210 GPa

Table 2 Other Component Material Properties (Plain Carbon Steel)

Mass Density	7800 kg/m^3
Tensile Strength	400 MPa
Yield Strength	220 MPa
Shear Modulus	79 MPa
Modulus of Elasticity (E)	210 GPa
Poisson Ratio	0.28
Specific Heat Capacity	0.43
Thermal Conductivity	43 W/mk

Having prepared a meshable, but not yet meshed geometry, we now define materialproperties (these can also be imported from a CAD model), loads and restraints, andprovide information on the type of analysis that we wish to perform.

Static study is the only type of study available in some SOLIDWORKS packages.Working with Static study we need to accept important limitations: material isassumed as linear, and loads are static.

Linear material

Whatever material we assign to the analyzed parts or assemblies, the material isassumed to be linear, meaning that stress is proportional to the strain (Figure 6).

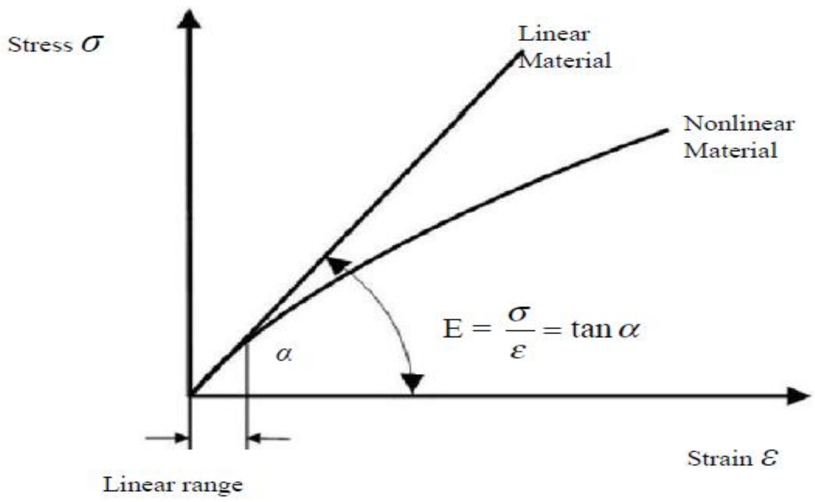

Fig. 6The linear material model assumed in SOLIDWORKS Simulation

With a linear material, stress is linearly proportional to strain. The linear range iswhere the linear and nonlinear material models are not significantly different.Using a linear material model, the maximum stress magnitude is not limitedto yield or to ultimate stress as it is in reality. Material yielding is not modeled, andwhether or not yield may in fact be taking place can only be established based on thestress magnitudes reported in results. Most analyzed structures experience stressesbelow the yield stress, and the factor of safety is most often related to the yield stress.Therefore, the limitations imposed by linear material seldom impede SOLIDWORKSSimulationProfessional users.

4) Create mesh.

Beam elements

Beam elements are created by meshing curves (wire frame geometry). They are a natural choice for meshing weldments. Assumptions about the stress distribution in two directions of the beam cross section are made. A beam element does not have any physical dimensions in the directions normal to its length. It is possible to think of a beam element as a line with assigned beam cross section properties.

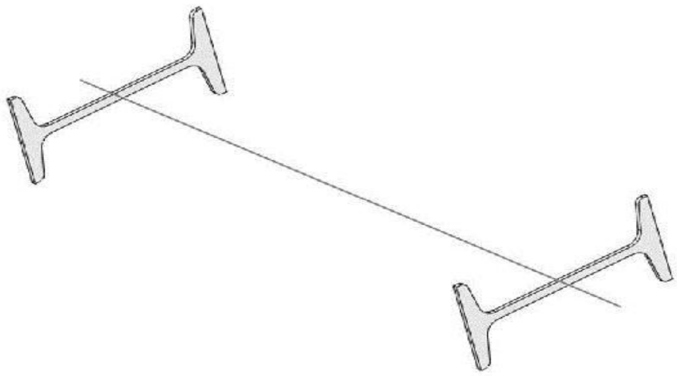

Fig.7 Conceptual Representation of a Beam Element

Solid mesh which is programme generated.

Fine Meshing is apply

No. of Nodes:- 74705

No. of Elements:- 42170

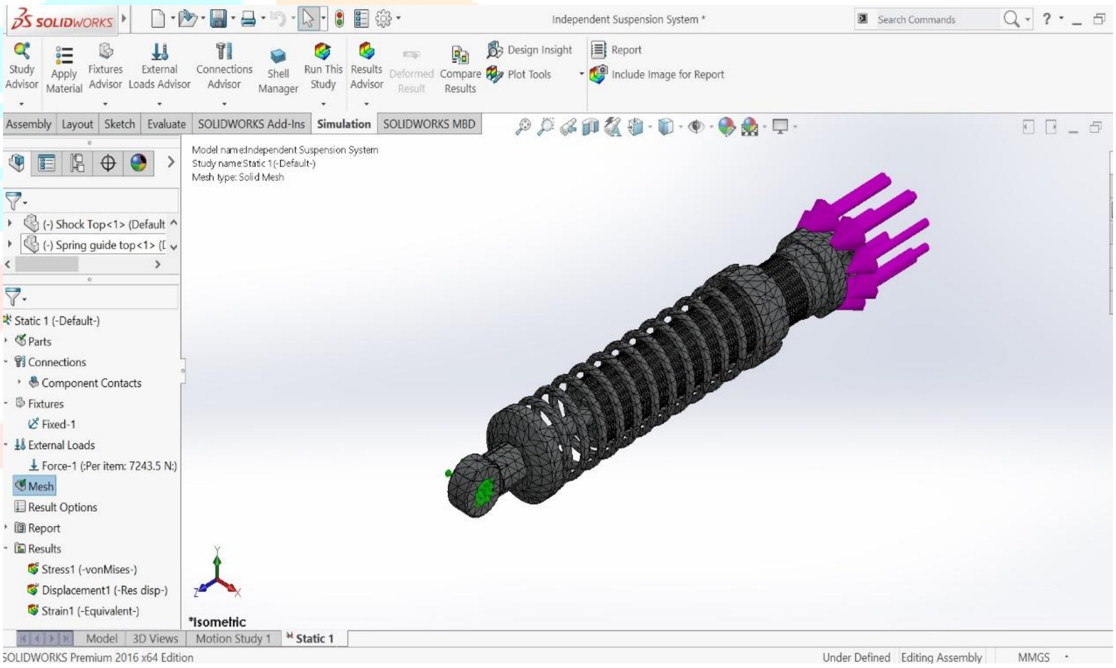

Fig.8 Meshing of Macpherson Strut Suspensionusing static analysis

5) Define Boundry condition

Apply fixed support at end of bottom of end strude which fixed on wheel shaft for connection of wheel to steering.

Before we proceed with the classification of finite elements we need to introduce theconcept of nodal degrees of freedom which are of paramount importance in FEA. Thedegrees of freedom (DOF) of a node in a finite element mesh define the ability of thenode to perform translation and rotation. The number of degrees of freedom that anode possesses depends on the element type.

In SOLIDWORKS Simulation, nodesof solid elements have three degrees of freedom, while nodes of shell elements havesix degrees of freedom.This is because in order to describe the transformation of a solid element from theoriginal to the deformed shape, we only need to know three translational componentsof nodal displacement. In the case of shell and beam elements, we need to know thetranslational components of nodal displacements and the rotational displacementcomponents.

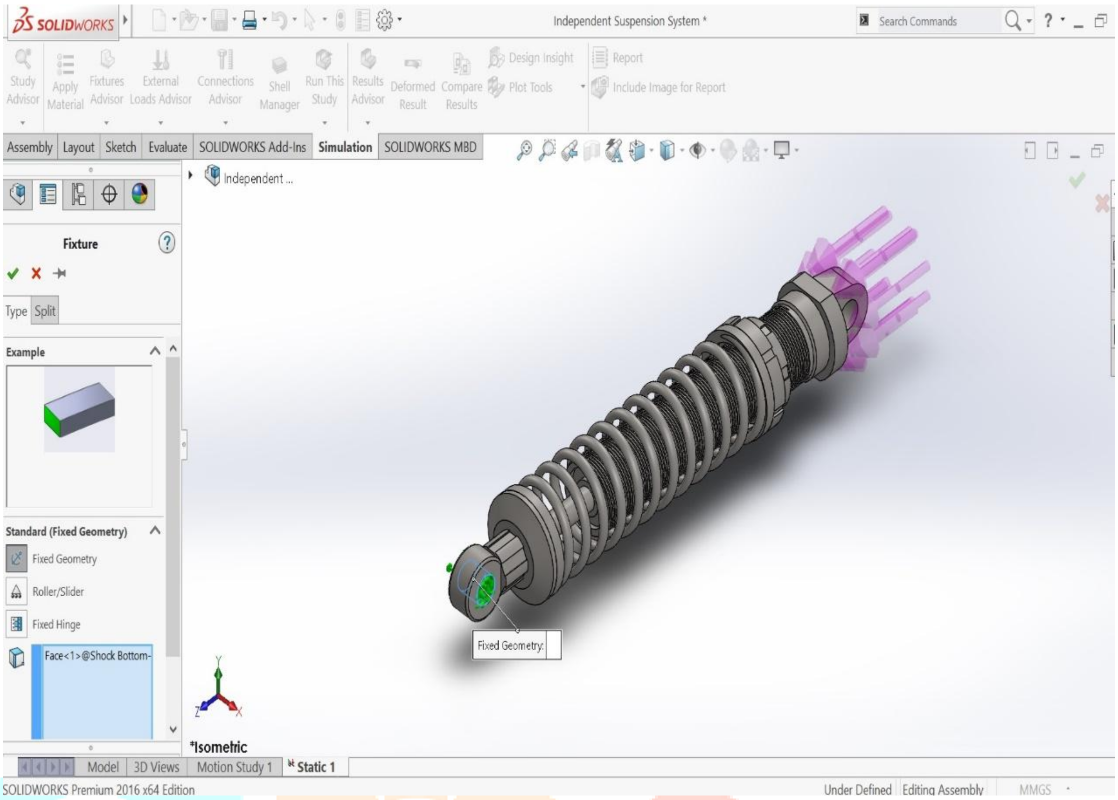

Fig. 9 Boundary condition of Macpherson Strut Suspensionusing static analysis

Apply Force

Consider car weight as static condition 3256 pound which convert into kg so magnitude of force for each wheel is 7243.5 N.

Static loads

All structural loads and restraints are assumed not to change with time. Dynamicloading conditions cannot be analyzed with Static study. This limitation implies thatloads are applied slowly enough to ignore inertial effects.

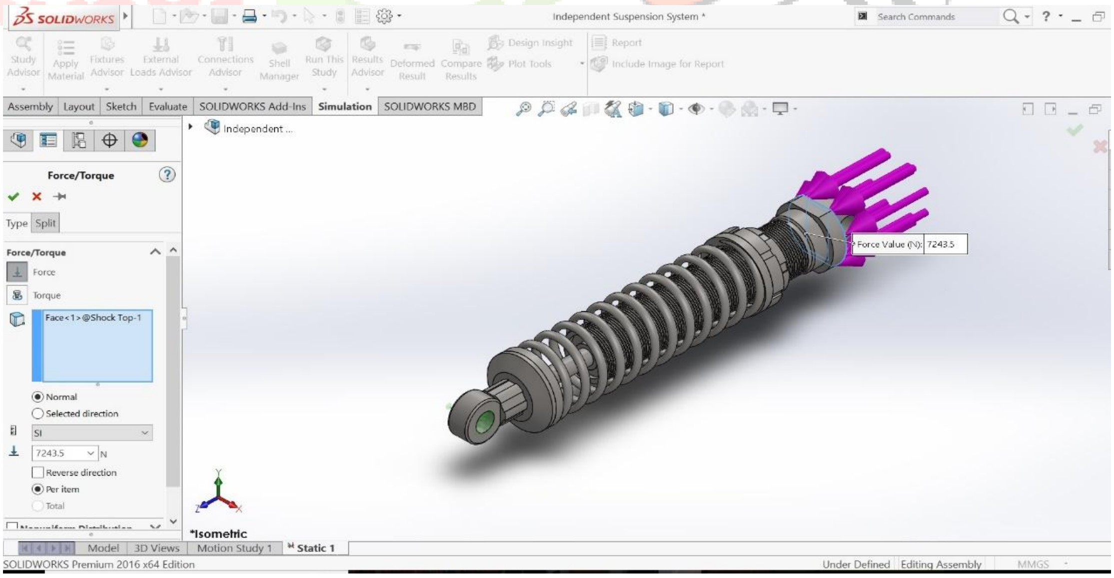

Fig. 10 Force applying on Macpherson Strut Suspension

Results of Analysis

Equivalent Stress for static annalysis

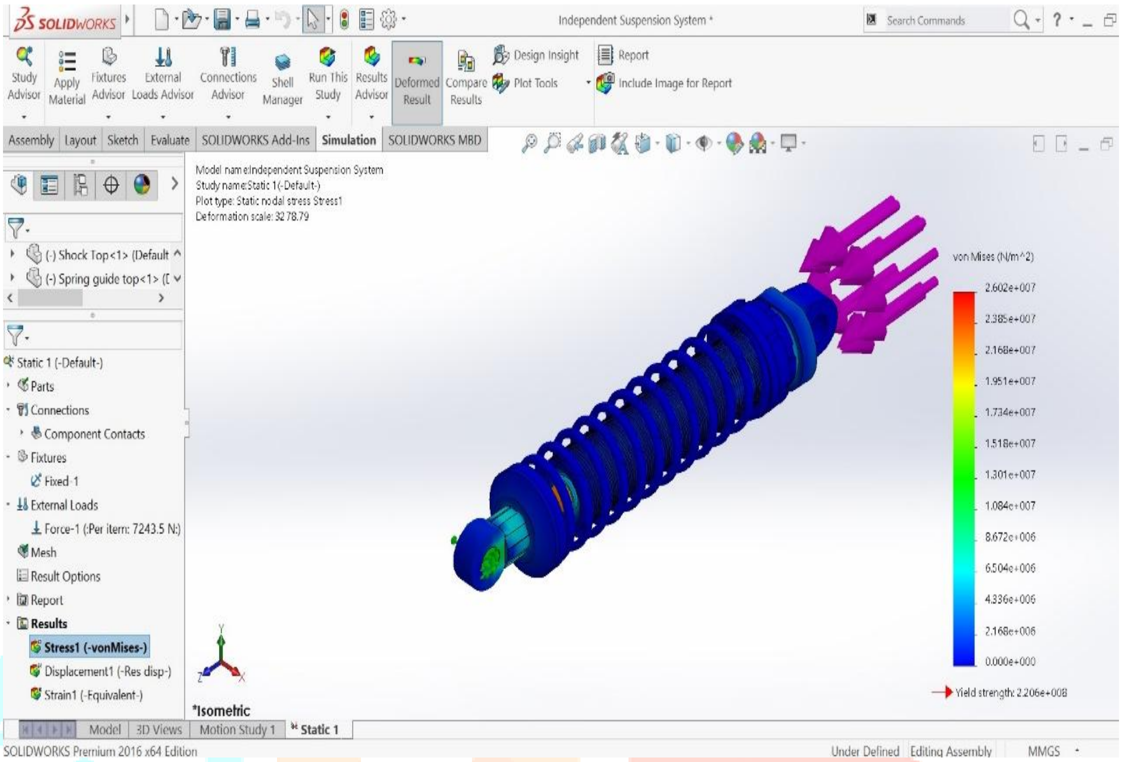

Fig. 11Von mises Stress analysis of Macpherson Strut Suspension

Total Deformation

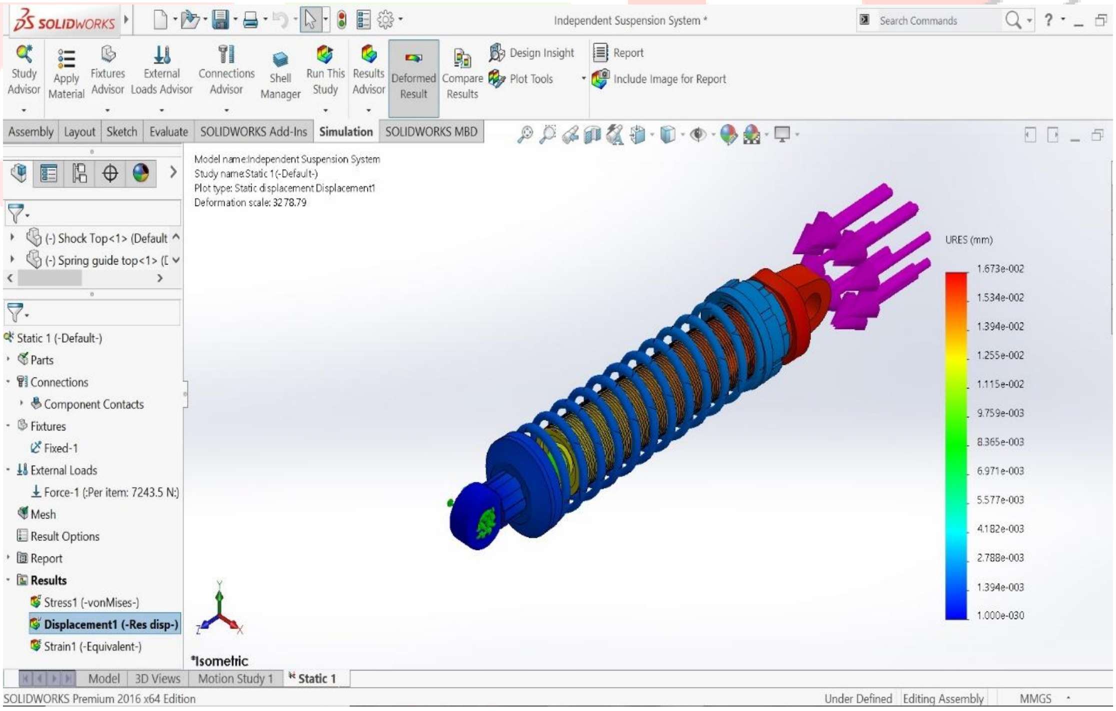

Fig.12 Deformation of Macpherson Strut Suspension

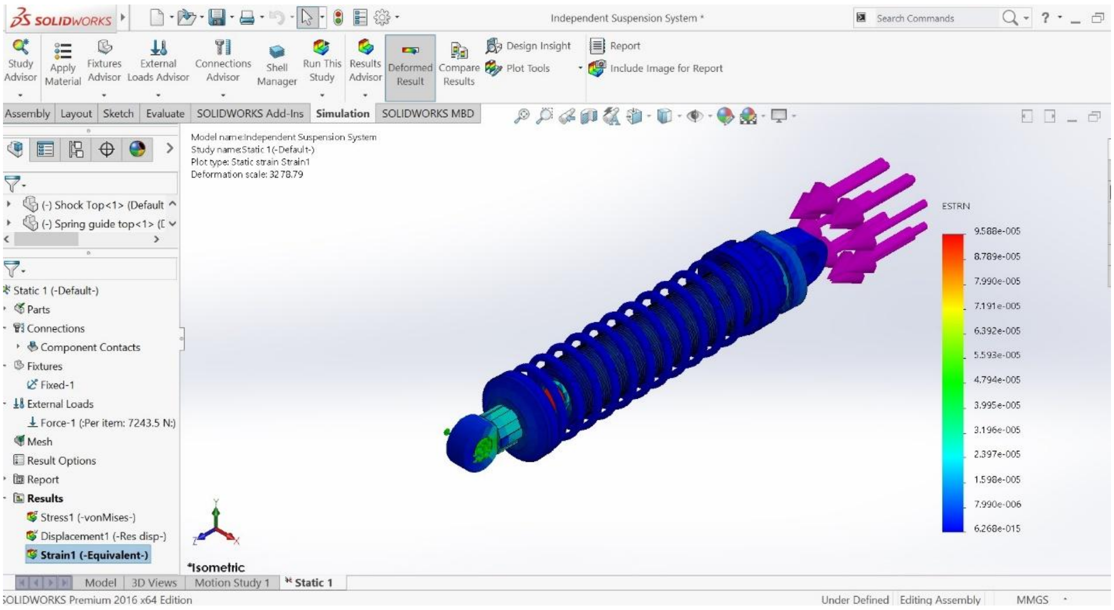

Fig.13 Strain of Macpherson Strut Suspension

Table 3Result

Stress in MPa	Deformation in mm	Strain
26.01	0.0167297	0.0958758

4. Conclusion

By using Solid work 2016 for CAD modelling as per design consideration of Macpherson Strut Suspension as functional analysis in consideration as static analysis to gives von mises stress, deformation and strain are 26.01MPa, 0.0167297mm and 0.0958758 respectively.

5. References

[1] Mahmoud Omar, M.M. El-kassaby, WalidAbdelghaffar, " A universal suspension test rig for electrohydraulic active and passive automotive suspension system", Alexandria Engineering Journal (2017) xxx, xxx–xxx.

[2] Tian Mi, Gabor Stepan, Denes Takacs, Nan Chena, Ning Zhanga," Model Establishment and Parameter Analysis on Shimmy of Electric Vehicle with Independent Suspensions", Procedia IUTAM 22 (2017) 259 – 266.

[3] Carlos Arana, Simos A. Evangelou, Daniele Dini," Series Active Variable Geometry Suspension application to comfort enhancement", Control Engineering Practice 59 (2017) 111–126.

[4] Jan Dizo, StasysSteisunas, Miroslav Blatnicky, "Vibration analysis of a coach with the wheel-flat due to suspension parameters changes", Procedia Engineering 192 (2017) 107-112.

[5] Anirban. C. Mitra, Gourav. J. Desai, Saaish. R. Patwardhan, Parag H. Shirke, Waseem M. H. Kurne, Nilotpal Banerjee," Optimization Of Passive Vehicle Suspension System By Genetic Algorithm", Procedia Engineering 144 (2016) 1158 – 1166.

[6] A.A. Koshurina, M.S. Krasheninnikov, R.A. Dorofeev,"Strength Calculation and Analysis of Equalizer Beam Embodiments for the Operated Equalizing Beam Suspension of the Universal Rotor-Screw Rescue Vehicle for the Arctic", Procedia Engineering 150 (2016) 1263 – 1269.

[7] PanosBrezas, Malcolm C. Smith, Will Hoult," A clipped-optimal control algorithm for semi-active vehicle suspensions: Theory and experimental evaluation", Automatica 53 (2015) 188–194.

[8] Werner Scheele, Igor Iroz," Uncertainties in road vehicle suspensions", Procedia IUTAM 13 (2015) 151 – 159.

[9] M. Soleymani, M. Montazeri-Gh, R. Amiryan,"Adaptive fuzzy controller for vehicle active suspension system based on traffic conditions", ScientiaIranica B (2012) 19 (3), 443–453.

[10] VladimírGoga, Marian Klúcik," Optimization of vehicle suspension parameters with use of evolutionary computation", Procedia Engineering 48 (2012) 174 – 179.

[11] SamantSaurabh Y., Santosh Kumar, Kaushal Kamal Jain, Sudhanshu Kumar Behera," Design of Suspension System for Formula Student Race Car", Procedia Engineering 144 (2016) 1138 – 1149.

[12] KameshJagtap, YogeshRathod, AnmayShedge, MitaliGramopadhye, Prof.VivekDiware," Suspension System For An All-Terrain Vehicle: A Review", International Journal of Engineering Research and General Science Volume 4, Issue 3, May-June, 2016.

[13] Prof. Sameer Verma, Parvez Raza, "Theoritical Analysis of Macpherson Suspension System", IJSART - Volume 2 Issue 3 –MARCH 2016.

[14] Reena Mishra, AnandBaghel," Design, Analysis and Optimization of front suspension wishbone of BAJA 2016 of Allterrain vehicle- A Review", IJRMMAE, Vol. 2 Iss.3, pp. 40-52, 28th Feb, 2017.

[15] Dongchen Qin, Junjie Yang, Qiang Zhu, Peng Du, "Simulation and Optimization of MPV Suspension System Based on ADAMS", 11th World Congress on Structural and Multidisciplinary Optimisation 07th -12th, June 2015, Sydney Australia.

[16] Jihui Liang, Lili Xin," Simulation analysis and optimization design of front suspension based on ADAMS", MECHANIKA. 2012 Volume 18(3): 337-340.

[17] P. Nagarjuna, k. Devaki Devi, "Design And Optimization Of Sheet Metal Control Arm For Independent Suspension System", International Journal of Engineering Research and Applications, Vol. 2, Issue5, September- October 2012, pp.535-539.

[18] Mohammad ImanMokhlespourEsfahani, MasoudMosayebi, "Optimization of Double Wishbone Suspension System with Variable Camber Angle by Hydraulic Mechanism", World Academy of Science, Engineering and Technology 61 2010.

[19] Arvin Niro, "Design and Development of A Suspension System Used in Roughterrain Vehicle Control For Vibration Suppression in Planetary Exploration".

[20] Asoc. Prof.Dr.Naser LAJQI, Asoc. Prof.Dr.Azem KYÇYKU, Ass. Prof.Dr.Shpetim LAJQI, "Design Process for The Suspension System of The Terrain Vehicle With Four Wheel Drive", Scientific Proceedings Xiv International Congress "Machines. Technologies. Materials." 2017 - Summer Session.

[21] http://www.autoevolution.com/news/how-multi-link-suspension-works 7804.html/[28.01.2012].

[22] Race Car Vehicle Dynamics by Milliken