Design and Analysis of Suspension System

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Abstract

An Independent wheel suspension system is used nowadays in almost all new modern cars. A conventional system that uses dependent suspension is not of much use as it creates more jerks in the car body. Normally, when any bump or hindrance comes across the vehicle, the suspension system reduces the disturbance in the car. The dependent system relates to chassis and car body frames. So, with any jerk, the car body faces the disturbance. In Independent wheel vehicle suspension, the spring relates to the wheel, which absorbs all shock and does not allow any jerk in the car body. The research work covered a brief literature review on the analysis of an 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 tools like Solid work for a critical component of independent suspension for analysis purposes and according to result for the conclusion.

Keywords: Design, Analysis, CAD Tools, Independent Suspension System, Mechanism.

1. Introduction

A 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. The 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 wear.
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 a different type of suspension system, 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.

1.1 Classification of Suspension System

The suspension system is always derived in some mechanical ways. The designs of the suspension systems are classification in two main groups:

- Dependent suspension system (solid axle) and
- Independent suspension system.

Each group can be functionally quite different, and they are studied and discussed accordingly. Recently, both suspension systems can be found on ordinary vehicles and commercial vehicles.

1.2 The Dependent Suspension System

The dependent suspension system is known as a solid axle when both wheels (left and right) are mounted the same solid axle (Figure 1). In this case, any movement of any wheel will be transmitted to the opposite wheel causing them to camber together. Solid drive axles usually are used on the rear axle of many passenger cars, trucks, and the front axle in many four-wheel-drive vehicles [13].

The advantage of solid axles is considered the camber angle which is not affected by the rolling of the vehicle body. Therefore, produce little camber in cornering, except for that which arises from slightly greater compression of the tires on the outside of the turn. Besides, wheel alignment is readily maintained, which contributes to minimize tire wear. The disadvantage of solid steerable axles is their susceptibility in shimmy steering vibrations, heavy mass, etc. The most types of solid axles are Hotchkiss, Four links and De Dion.

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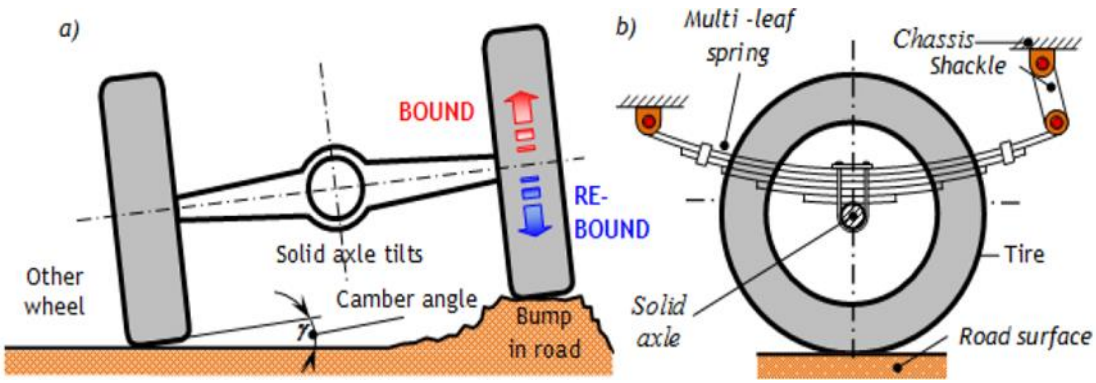

Fig. 1. The dependent suspension system (solid axle); a) Front view and b) Side view

1.3 The Independent Suspension System

The independent suspension system allows one wheel to move upward and downward with a minimum effect on the other wheel (Figure 2). Most of the passenger cars and light truck use independent front suspension system because provide much more space for installing vehicle engine, allow much more displacement of the wheel, better resistance in steering vibration (wobble and shimmy) as well as offer higher performance in passenger comfort. As disadvantages of the independent suspension system can be considered the complexity of the design and manufacturing cost due to an increasing number of parts.

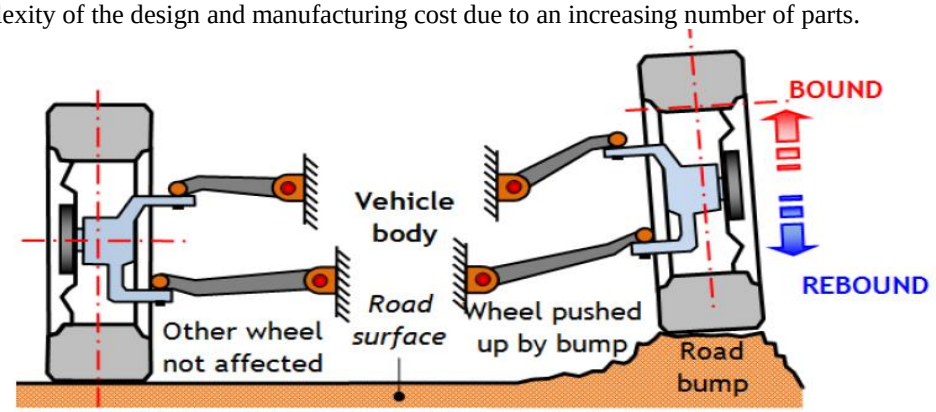

Fig. 2. The independent suspension system (front view)

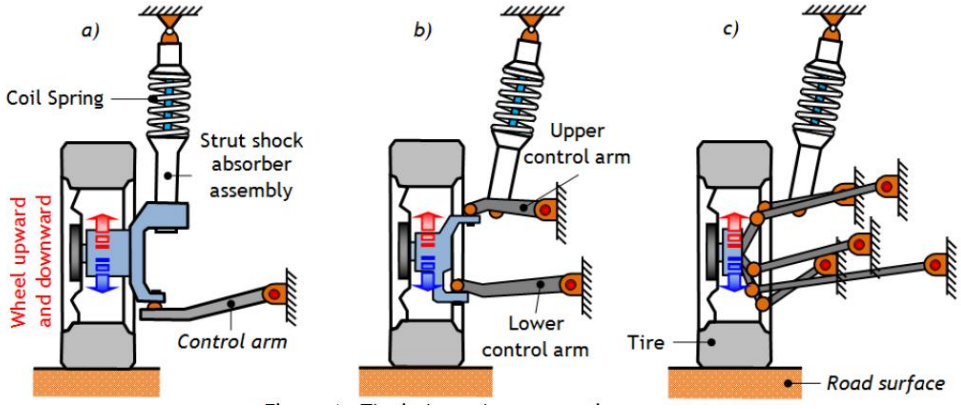

Fig. 3. The independent suspension system.
a) MacPherson strut, b) double wishbone and c) multi-link suspension system

Over the years, many types of independent suspension systems have been tried to develop such as MacPherson, double wishbone, multi-link, trailing arm, and swing axle. Many of them have been discarded for different reasons, with only basic concepts, MacPherson strut, double wishbone, and multi-link suspension system have found application in many types of vehicles [1][2].
The MacPherson strut consists of a single control arm and a strut assembly (spring and shock absorber) which allows tire and wheel to move upward and downward. The major components of the system are shown in Figure 3.a. It may be used on both the front and rear axles. This suspension system design allows reducing the number of parts, lower un-sprung mass as well as smooth driving comfort.

McPherson strut, a clever compromise that permits reasonable performance compare by low cost but never matches the performance or adjustability such as double wishbones or multi-link suspension system. Furthermore, this type of suspension requires sufficient vertical space and a strong top mount[4] [6].

2. CAD Tool-Solid Work 2020

Solid Works 2020 is a 3D mechanical design system built with adaptive technology and solid modeling capabilities.
The Solid Works 2020 software includes features for 3D modeling, information management, collaboration, and technical support with DSS you can:

1. Create 3D models and 2D manufacturing drawings.
2. Create adaptive features, parts, and subassemblies.
3. Manage thousands of parts and large assemblies.
4. Use third-party applications, with an Application Program Interface (API).
5. Use VBA to access the Autodesk Inventor API. Create programs to automate repetitive tasks. On the Help menu, choose Programmer Help.
6. Import SAT, STEP, and AutoCAD and Autodesk Mechanical Desktop (DWG) files for use in Autodesk Inventor. Export Autodesk Inventor file to AutoCAD, Autodesk Mechanical Desktop, and IGES formats.
7. Collaborate with multiple designers in the modeling process.
8. Link to web tools to access industry resources, share data, and communicate with colleagues.
9. Use the integrated Design Support System (DSS) for help as you work.

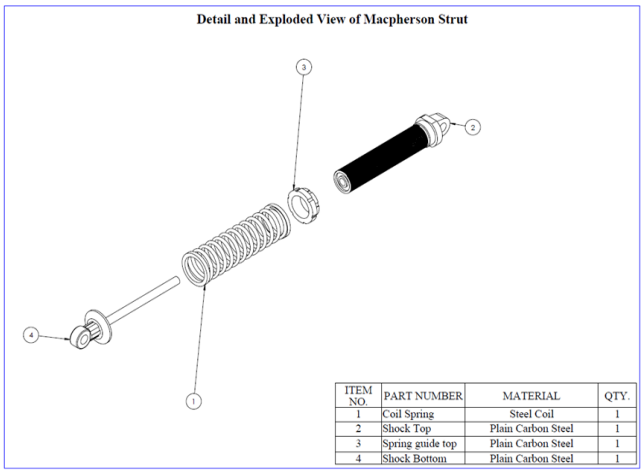

Fig. 4. Exploded View of Macpherson Strut Suspension

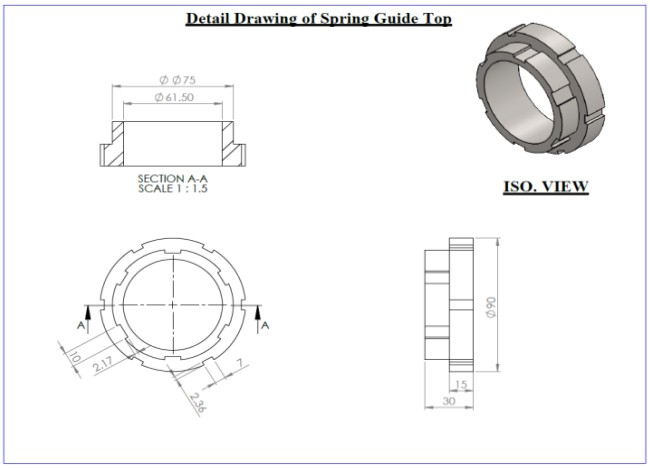

Fig. 5. Detail drawing of Spring Guide Top

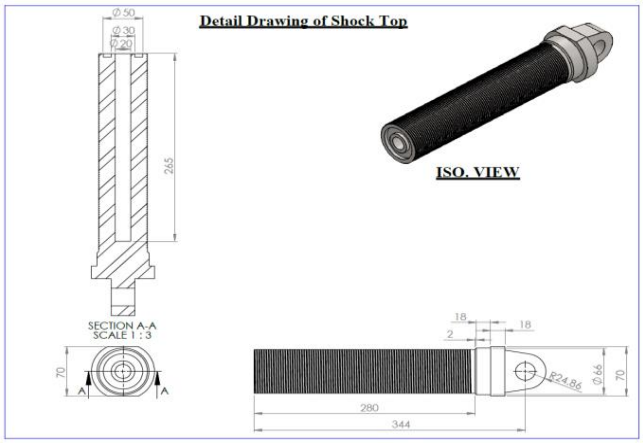

Fig. 6. Detail drawing of Shock Top

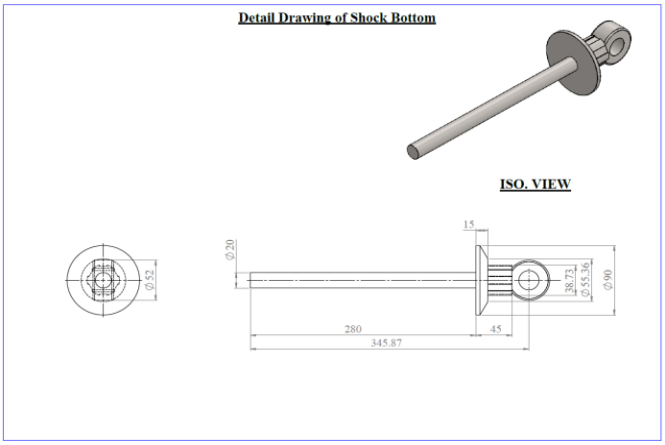

Fig. 7. Detail drawing of Shock Bottom

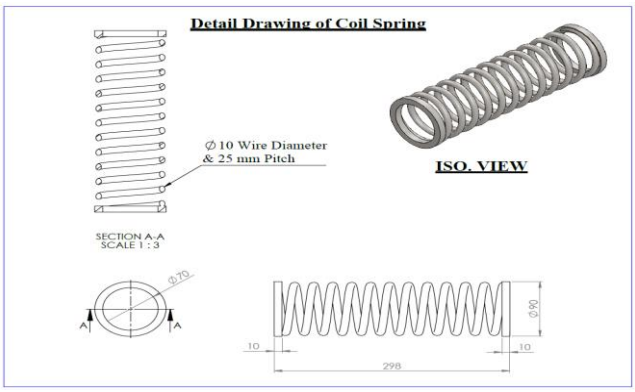

Fig. 8. Detail drawing of Coil Spring

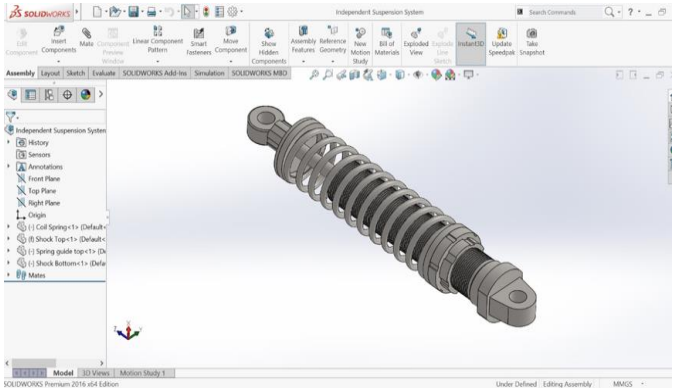

Fig. 9. Isometric view of Macpherson Strut Suspension

Fig.4 is reflected exploded view of Macpherson Strut Suspension. As shown in Fig. 8 to 8, there is the detail of different components of Macpherson Strut Suspension. Using part features creates all components of the structure. All assemblies are created using various components (part) by constrained their relative motion.

Using part modeling environment to create part modeling. First to make the geometry of sketch with respect their practical data to measure the thickness of plate and amount of extruded part by using extrude command in feature operation. Further using the new sketch on the base extruded component and sketch an existing extruded feature to identifying model width.

3. Finite Element Analysis (FEA)

Solid Works 2020 precision finite element model-building tool offers many design scenarios and mesh enhancement capabilities. Solid Works 2020 enables several design classes, including 2- and 3-D surface and solid models, beam or truss and plate/shell. Solid Works 2020 also enables engineers to build compound models having mixed element types. Solid Works 2020 provides access to Merlin Meshing Technology for automatic surface mesh enhancement or enables engineers to work directly on an FEA model surface for manual mesh enhancement. Engineers can choose tetrahedral, brick or hybrid (bricks outside and tetrahedral inside) solid FEA meshes.

Solid Works 2020's linear static and dynamic stress analysis capabilities determine stresses, displacements and natural frequencies as well as predict dynamic response to static and dynamic loading. These capabilities are highlighted throughout this brochure. Solid Works 2020's FEA, Mechanical Event Simulation, modeling, and CAD/CAE interoperability tools are designed to help engineers develop products that are more reliable and less costly to produce with faster time-to-market. To provide the best cost/benefit solution for each customer, Solid Works 2020's High Technology Core Packages and Extenders can be purchased at special combination pricing or separately to best fit individual needs while allowing for future growth and change.

The finite element method (FEM), sometimes referred to as finite element analysis (FEA), is a computational technique used to obtain approximate solutions of boundary value problems in engineering. Simply stated, a boundary value problem is a mathematical problem in which one or more dependent variables must satisfy a differential equation everywhere within a known domain of independent variables and satisfy specific conditions on the boundary of the domain. Boundary value problems are also sometimes called field problems. The field is the domain of interest and most often represents a physical structure.

The field variables are the dependent variables of interest governed by the differential equation. The boundary conditions are the specified values of the field variables (or related variables such as derivatives) on the boundaries of the field. Depending on the type of physical problem being analyzed, the field variables may include physical displacement, temperature, heat flux, and fluid velocity to name only a few.

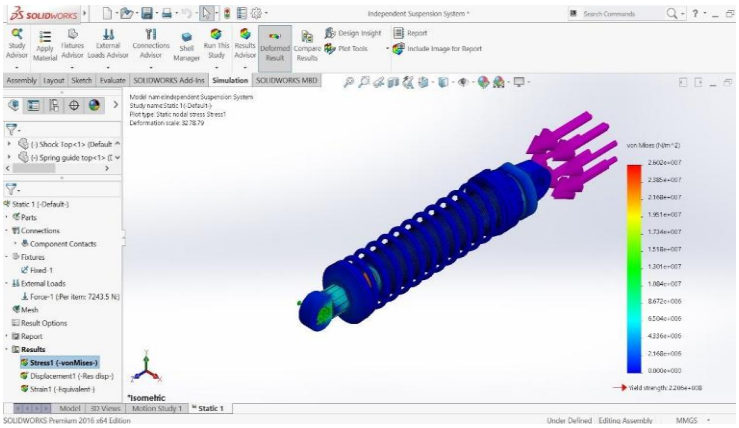

Fig. 10. Von mises Stress analysis of Macpherson Strut Suspension

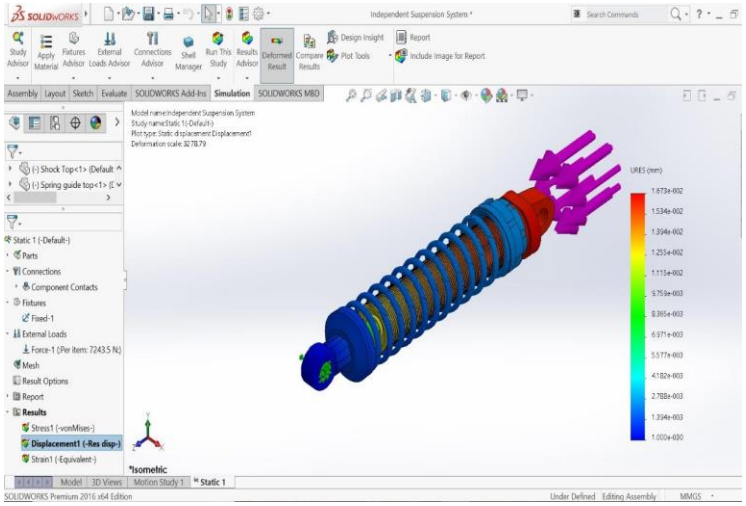

Fig. 11. Deformation of Macpherson Strut Suspension

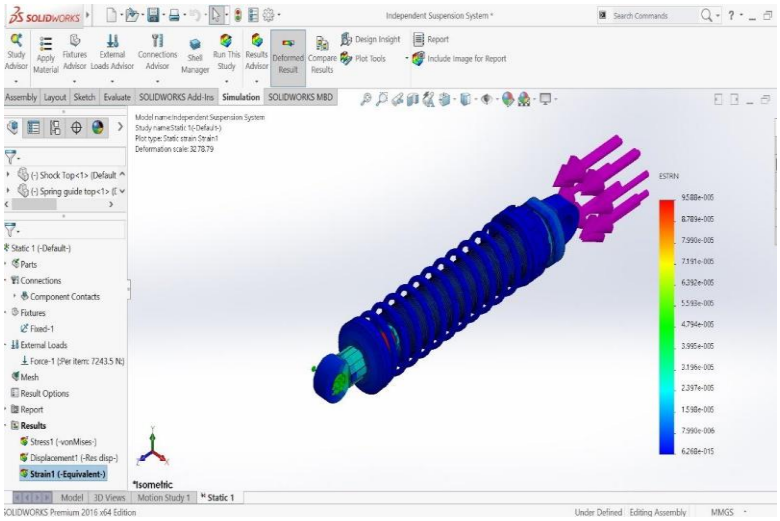

Fig. 12. Strain of Macpherson Strut Suspension

Table 1. Result

Stress in MPa	Deformation in mm	Strain
26.01	0.0167297	0.0958758

4. Conclusion

The research survey was reflected in different types of suspension systems for the different vehicles but here focused on an independent wheel vehicle suspension system.

It was reflected on design and analysis of suspension of such vehicle likes Formula Student Race Car, An All-Terrain Vehicle, BAJA 2016 of Allterrain vehicle and Terrain Vehicle with Four Wheel Drive.

It was reflected in the design and analysis of suspensions such as analysis methods likes Model Establishment and Parameter Analysis, Vibration Analysis, etc.

Some research papers indicated optimization methods like Adaptive fuzzy controller, clipped-optimal control algorithm, Genetic Algorithm, etc.

Some research papers indicated real data analysis like a universal suspension test rig.

Some research papers indicated an analysis of such a suspension system like Double Wishbone Suspension System, MPV Suspension System, etc.

By using Solid work 2020 for CAD modeling 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.

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