

A Review on suspension system design

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Abstract:

This paper presents various aspects of suspension system and the work done by various researchers in this area. A suspension system isolates the vehicle from wheel and road vibration and absorbs most of the shock. In this paper a review has been done of various suspension systems and their design configurations. Various researchers have done it's designing in various softwares like Solid works. Different design parameters have been reviewed and optimization of the major parameters are shown as given by researchers that affect suspension over Solid-Work Software. The relationship between these factors and their affects have been reviewed in brief.

Keywords: Suspension system, Control springs, Wishbone suspension

Introduction:

The suspension system is one of the most important systems to consider when designing a car. The car will not perform up to its full potential, if the suspension does a poor job. So, suspension components are first designed using certain assumptions and other criteria and are then analysed to obtain final optimized components of suspension system. Suspension is the key to connect car chassis with the wheels and has relative motion between them. Suspension is a device for guiding the wheel kinematically relative to the chassis. To support vehicle weight in all driving possible conditions. To optimize the tire contact with the respective surface. To maintain the wheel plan in a good configuration of steering and camber angle with respect to the ground. To oppose a reaction to longitudinal and lateral forces produced at the tire contact patch. To keep rolling movements when pitch (dive under braking and squat under acceleration) and cornering (lateral acceleration). To isolate the case of road irregularities to ensure passenger comfort to ensure the passengers safety by maintaining the integrity of the vehicle during impact.

Types of Suspension System:-

1. WISHBONE SUSPENSION SYSTEM: -

- This is also called as parallel link type suspension system. This is the most popular suspension system. This system used coil springs in common for this type suspension.
- The Vehicle weight is transmitted from the body and cross member to the coil spring through the lower wishbone.
- The shock absorber is placed inside the coil spring and it is attached to cross member and lower wishbone
- The upper wishbone member is shorter than the lower wishbone member

2. MAC PHERSON STRUT SUSPENSION SYSTEM:-

- In this system used only lower wishbone only, so it is also called single wishbone suspension system.
- This is simple construction rather than others
- This system used in Maruti – 800cc cars
- This system contains roll bar to provides increase road safety, improve ride comfort, light and self-stabilizing steering

3. VERTICAL GUIDED SUSPENSION SYSTEM: -

- In this suspension the king pin is directly attached to the cross member of the frame
- It can be slide up or down corresponding or elongation the springs
- In this system, the wheel track, the wheel base and wheel altitude remain unchanged
- This system is only disadvantages is less stability

4. TRAILING LINK SUSPENSION SYSTEM: -

- In this type of suspension, a helical coil spring is arranged in horizontal position rather than the vertical position
- One end of the spring is fixed to cross member of the spring and other end with one end of trailing link
- The other end of the trailing link is attached to the shaft which carries wheel hub
- When the wheel moves up and down, it winds and un winds the helical spring to absorb shocks due to road irregularities
- To check the vibrations of the spring by multi – plate shock absorber is located at the end of the cross member

5. SWINGING HALF AXLES SUSPENSION SYSTEM: -

- In this type of suspension system, the wheels are rigidly fixed on the half axles, so it is called as the swinging half axles suspension
- The half axles are pivoted on chassis member at the centre of the car
- The half axles are connected with the coil spring and shock absorber to frame
- It is very simple construction but main disadvantage is to vary the chamber angle

6. AIR SUSPENSION SYSTEM: -

- Comprises of compressor, supplying air to air tank
- Pressure maintained – 5.6 to 7 kg/sq.m
- As load applied, air bags compressed actuating the levelling valve
- Air from the tank fills the compressed air bag and hence raise the level of the frame
- Air from air bag gets released as load on chassis decreases

7. HYDROLASTIC SUSPENSION SYSTEM: -

- A system where the front and rear suspension systems were connected together in order to better level the car when driving
- The front and rear suspension units have Hydrolastic displacers, one per side
- These are interconnected by a small-bore pipe and each displacer incorporates a rubber spring
- Damping of the system is achieved by rubber valves

8. RIGID SUSPENSION SYSTEM: -

- Non – independent / Rigid suspension has both right and left wheel attached to the same solid axle
- When one wheel hits a bump in the road, its upward movement causes a slight tilt of the other wheel
- This system is simple construction but less comfort due to low sprung and un sprung weight
- It is used in truck's front and rear axle suspension and also used in car's rear wheel suspension
- It is used in heavy duty vehicle suspension system

Advantages:

- Control spring and suspension movement
- Provide consistent handling and braking
- Prevent premature tire wear
- Help keep the tires in contact with the road
- Maintain dynamic wheel alignment
- Control vehicle bounce, roll, sway, drive, and acceleration squat
- Reduce wear on other vehicle systems
- Promote even and balanced tire and brake wear

Applications:

- Supports the weight
- Provides a smooth ride
- Allows rapid cornering without extreme body roll

- Keeps tires in firm contact with the road
- Allows front wheels to turn side to side for steering
- Works with the steering system to keep the wheels in correct alignment
- Isolate passenger and cargo from vibration and shock

SWOT Analysis:

Strength: -

- Variable space for wheel deflection is put for optimum use for automatic height control.
- Head light alignment does not vary due to different loading condition.
- It improves the ride comfort.
- Reduce noise in suspension system.

Weakness: -

- Higher initial cost.
- Occupies more space.
- Maintenance cost is more.
- Due lack of friction damping is necessary due road shock.

OPPORTUNITIES: -

- The suspension system plays a vital role in the pace of growth in automobile industry.
- In future the auto suspension system will be introduced where it will serve its best in production and efficient enough to fit in a vehicle.
- Suspension system holds the grip in ties up and in collaboration of various automobile companies for better product and future plans.

Threats: -

- The product acceptance in the market and also in big industries which can also lead to a huge competition among the companies.
- The prototype of suspension system may not meet the assumptions made.
- Long existence period in the industries.
- Lack of possibility to build replicated product with the same material and this would lead to a big challenge for the companies.

Contributions of various researchers:

Padraig Dowds et al. [1] investigated on Modelling and control of a suspension system for vehicle applications and gave review it. They concluded that the active suspension system facilitates significantly improved regulator response when compared to the passive suspension system. The controlling element of the active suspension system is generally based on an actuator; the main practical difficulty in implementing active suspension is the power consumption of the actuator.

Faraz Ahmed Ansari et al. [2] investigated on control of active suspension system using sliding mode control. They concluded the chattering problem has been overcome by using the continuous switching function and the boundary layer that can be adjusted by varying the sliding gain in the controller.

A G Thakur et al. [3] investigated on Simulink Model of Suspension System and its Validation on Suspension Test Rig and gave review it. They concluded that the sprung mass goes on increasing then vertical acceleration sharply decreases. But sprung mass can't be increased beyond 175Kg otherwise the high dynamic forces strikes the shaker. Thus, high sprung mass gives comfort but striking of sprung and unsprung mass should not take place.

N. Lavanya et al. [4] investigated on Design and Analysis of a Suspension Coil Spring for Automotive Vehicle and gave review it. They concluded that the strain and strain response of spring behaviour will be observed under prescribed or expected loads and the induced stress and strains values for low carbon structural steel is less compared to chrome vanadium material also it enhances the cyclic fatigue of helical spring.

Prakash Kumar Sen et al. [5] investigated on Components, Principal and Classification of Suspension System and gave review it. They concluded that the suspension system provides the vehicle acts as a safety member by providing the desired height and the cushioning against the bumps or irregularities present on the road surface. The suspension system absorbs the energy generate due to road irregularities or bumps, pits etc and these energies are transferred from the vehicle to the earth or road.

Khatavkar et al. [6] investigated on Electromagnetic Suspension System and gave review it. They concluded that the Semi-active suspension system has better performance capabilities over passive suspension system and electromagnetic suspension, it has high bandwidth and efficient solutions for improving handling and comfort.

Chaudhari Mahendra M [7] investigated on Indian automobile suspension system and gave review it. They concluded that Indian suspension system are very useful in all passenger vehicles as well as number of suspension system are utilized to variety of vehicle structure and application base. This suspension system provides high degree of comfort and it reduces the shocks and vibrations coming to the vehicle body. Due to reduced vibration the maintenances of the vehicle are decreases, hence reduces the operating cost. Due to the self- adjusting technique, increases the flexibility of any kind of roads.

Aniket Bharambe [8] investigated on Magnetic Suspension for Motorcycles and gave review it. They concluded that the magnetic suspension is a revolutionary idea which will provide a comfortable ride by minimizing the vibrations and other factors. It would also allow to set the suspension stiffness as per requirement. Thereby magnetic suspension will be a best substitute for current problems and providing ultimate vehicle dynamics.

Nikhil et al. [9] investigated on Control strategies and models for suspension system and gave review it. They concluded that suspension system covers a board range of design issues and challenges. As degrees of freedom goes on increasing from one degree to four, seven, eight etc. Complexity in analysis increases. While two – degree of freedom suspension system can give effective performance measurement with less complexity and simple structure.

Dishant et al. [10] investigated on various suspension system in use nowadays and gave review it. They concluded that the suspension system provides the vehicle acts as a safety member by providing the desired height and the cushioning against the bumps or irregularities present on the road surface.

Lihle I et al. [11] In this paper they present a design and implementation of an energy efficient optimal controller for a constructed half-car suspension system. This paper shows a need for optimizing the amount of energy consumed by active suspension systems. An optimal control method was proposed which minimizes the suspension energy composed of the control signal and the car body displacement. The controller was evaluated for a half-car suspension model on MATLAB. The optimal controller showed significant reduction in energy through a defined performance index.

Abhishek Goyal et al. [12] investigated on active suspension control mechanisms and approaches. They concluded that Active Suspension Systems furnish much flexibility in enhancing ride and handling, but higher power requirements have limited its implementation.

Yousef Abdulhammed et al. [13] investigated on New Automotive Active Suspension System and gave review it. They concluded that electrical model is applied to the suspension system with the hydraulic actuator. The control input is design ed based on the model of PID control principle to minimize the tracking error between the actual force generated by hydraulic actuator and ideal force obtained by the combined suspension system with hydraulic cylinder

Ajat Sudrajat et al. [14] investigated on active suspension system and gave review it. They concluded that the progression in this technology field warrants analysis of possibility enforcing available active suspension systems with electromagnetic actuators to increase its performance without raising costs and energy consumption.

Vasamsetty Sreeram Santosh et al. [15] investigated on Design and Optimization of Suspension System for a Formula Hybrid Vehicle and gave review it. They concluded that the suspension stiffness and damping are obtained for good comfort and handling conditions. From results it is observed that soft spring gives good comfort i.e. less sprung mass.

Daniyan et al. [16] In this paper they investigated the amount of distortion, stress and temperature distribution during the welding assembly of the suspension system of a rail car. They concluded at a distance of 30 mm from the weld centre-line, the maximum temperature obtained is 700 °C and beyond this temperature, the material begins to melt. With the increase of temperature (°C) the flow stress (MPa) decreases. The material deforms elastically up to a temperature 900o C beyond which plastic deformation takes place at elevated temperature.

Tianhe Jin et al. [17] investigated on a versatile semi-active suspension system with variable stiffness (VS) magnetorheological elastomer (MRE) isolators and variable damping (VD) magnetorheological (MR) damper for high-speed trains, aiming to improve ride comfort by avoiding car body resonance and dissipating vibration energy. They concluded that that the system can avoid lateral resonance of the car body and dissipate the vibration energy efficiently. This system performs better in improving ride comfort of the high-speed train compared with the pure VS suspension, pure VD suspension, passive-off, and passive-on suspension systems.

S.F. Youness et al. [18] investigated on a simulation of two cases of control for a full model car active suspension system. The first case is a control system without network, while the second is a networked control system. They have concluded that LQR method to control the system allows more freedom in choosing the parameters for direct control, while PID can provide good results in case of controlling just the suspension travel.

Conclusion:

Suspension system is one of the most important systems to consider when designing a car. Suspension is the key to connect car chassis with the wheels and has relative motion between them. It is like white blood cell, as white blood cell provides energy to our body to fight against various viruses and diseases, in the similar way suspension system provides energy to vehicle to protect itself from damaging and ensures better handling of vehicles.

Electromagnetic active suspensions will be the future trend of automotive suspensions due to simple structure, high band width operation, accurate and flexible force control, high ride quality, good handling performance, and energy regeneration. The future research and development of electromagnetic active suspensions should focus on two aspects. One of which is to research and develop electromagnetic linear actuators and the other is to research and develop control for the electromagnetic active suspensions and system. The former includes configuration design, electromagnetic design, and design optimization for high force density.

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