

Suspension Systems: A Review

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Abstract - Suspension systems don't tend to get much publicity, but they're probably the most crucial factor in the day-to-day enjoyment of your car. Automakers are always tweaking and refining their designs in search of that elusive ideal: a perfect ride coupled with race-worthy handling. We haven't quite gotten there yet, but the latest systems are better than ever at reconciling the competing goals of comfort and performance. Like most other components on a vehicle, manufacturers have taken many different approaches when it comes to suspension design. Luxury cars are engineered for a comfortable ride, while sports cars need to corner at high speed. Trucks, on the other hand, need to carry heavy loads and may travel off the pavement.

Key Words: Active Suspensions, Vehicle System, Intelligent Control, Modernisation of Suspensions, Adaptive Control System

1.INTRODUCTION

Suspension is an arrangement of tires, tire air, springs, shock absorbers and linkages that connects a vehicle to its wheels and allows relative motion between the two. Suspension systems must support both road handling and ride quality, which are at odds with each other. The adjustment of suspensions involves finding the right understanding. It is important for the suspension to keep the road wheel in contact with the road surface as much as possible, because all the ground forces acting on the vehicle do so through the contact patches of the tires. The suspension also guards the vehicle itself and any belongings from damage and wear.

1.1 History of Suspension System

Horse-drawn carriages characterized the streetscape right up until the beginning of the 20th century, but the advent of the automobile, which Gottlieb Daimler and Carl Benz developed independently of each other in 1886, established a completely new set of requirements compared with those associated with horse-drawn carriages – in particular where the suspension was concerned: it was necessary to cope with higher speeds, without endangering road users. Gottlieb Daimler and Carl Benz adopted different approaches to this: while Benz took the bicycle as the starting point for his Patent Motor Car and used a steering head and wire wheels, Daimler's vehicle was based on a carriage equipped with a steering system. The technology evolved rapidly. In 1889, Wilhelm Maybach, Daimler's brilliant design engineer,

developed the "wire-wheel car". Like the Benz vehicle, this now also had a chassis which was completely divorced from the world of carriage building. There was also great progress in the development of the engines which became ever more powerful, making the cars faster, but also heavier – a factor which placed new demands on the suspension. The design engineers responded with increasingly sophisticated solutions. These included the gradual adoption of coil springs – on the rear axle of the Daimler belt-driven car of 1895, for example. However, it was not Gottlieb Daimler but Carl Benz who solved the problem of how to steer a

four-wheeled vehicle by developing the "double pivot" steering system. This new type of steering, used for the first time in the Victoria model, was filed as a patent by Benz in 1893.

The dawn of the 20th century saw the chain drive finally replaced by the shaft drive which was already to be found in the 1902 Benz Parsifal, the counterpart of the Mercedes Simplex. The new drive system made it necessary to adopt a new design for the entire rear axle assembly: the axle gear unit was now equipped with an integrated differential which increased the unsprung masses. As this meant that the rear axle required more damping, additional dampers were fitted.

1.2 How does the suspension system work?

The suspension control arms or links allow wheel movement independent of the body. This provides a mechanism to isolate body from the road bumps. The springs manipulate the frequency of road disturbances and try to bring them into a more manageable band. They also provide damping through friction (spring ends and the seat) and own hysteresis. The damper dissipates the energy of the dynamic load coming through the road bumps. Together, they try to eliminate the effects of road undulations on the ride as well as stability of the vehicle.

2. Literature Review

2.1. Different Types of Suspensions used in Automobile Industries:

- Dependent suspensions
- Independent suspensions
- Semi – independent suspensions

2.1.1. Dependent Suspension System :

This type of suspension system acts as a solid link between two wheels such that any movement of one wheel is translated to the other wheel. Also, the force is translated from one wheel to the other. Build upon suspension system is not suitable for ATVs where motion of the two wheels is needed to be self-reliant.

Following are the examples of dependent suspension system-

1. Leaf Spring Suspension. Used in Heavy duty vehicles (trucks, bus, etc.)
2. Push and pull rod Suspension. Used in racing cars.
3. Anti-Roll Bar Suspension. Used in luxury vehicles.

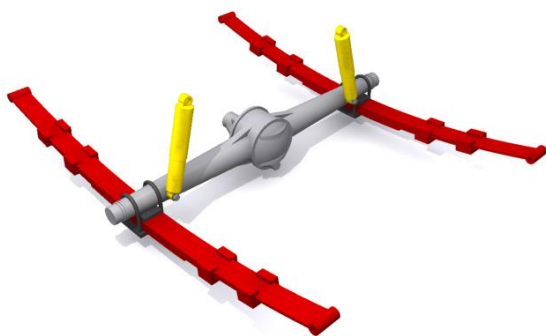


Fig - 1 : A Solid Axle (Type of a dependent suspension)

2.1.2. Independent Suspension System :

This type of suspension allows the wheel to travel without affecting the motion of opposite wheel. This is widely used suspension system in passenger cars, luxury cars and ATVs because of its advantages over dependent suspension system.

Following are the examples of independent suspension system-

1. Macpherson Suspension: Used in front suspension of most of the commercial cars.
2. Double Wishbone Suspension: Used in ATVs.
3. Trailing Arm Suspension. Used in rear suspension of most of the commercial cars.



Fig-2: McPherson Strut (A type of Independent suspensions)

2.1.3. Active Suspension System :

An active suspension system acquire the ability to reduce acceleration of sprung mass continuously as well as to minimize suspension deflection, which results in progression of tire grip with the road surface, thus, brake, grip control and vehicle maneuverability can be

Considerably improved. Today, an obstinate race is taking Place among the automotive industry so as to produce Highly developed models. One of the performances Concern is advanced suspension systems which Avoid the road disturbances to affect the passenger Amenity while increasing riding capabilities and performing a smooth drive. While the desire of the suspension system is to provide a smooth ride in the car and to help maintain control of the vehicle over rough field or in case of sudden stops, increasing ride comfort results in larger suspension stroke and smaller damping in the wheel hop mode. Many control methods have been urged to overcome these suspension problems. Many active suspension control access such as Linear Quadratic Gaussian (LQG) control, adaptive control, and non-linear control are developed and proposed so as to manage the occurring problems.

2.1.4. Active vehicle suspension model

The kinematic diagram of the investigated suspension is shown in Fig. 1. A quarter vehicle model Of a suspension is adopted, with bumped parameters. This is a 2 DOF model, where the first DOF, associated with the mass m_1 , represents the wheel with a tire. The wheel mass is unsprung. The second DOF, associated with the mass m_2 , represents the car body with passengers. This mass is introduced to as sprung mass. The main task is to minimize the vibrations of the mass m_2 , despite the continuing excitations w induced by road deviations.

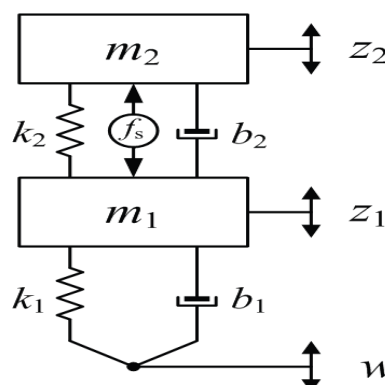


Fig-3: Quarter-vehicle full active suspension

The following designations are used:

- v - Voltage controlling the servo-valve, directly affecting the force f_s ,
- w - This input might be treated as excitation due to road unevenness,

z_2 - displacement of sprung mass (to be isolated from vibration).

2.1.5. Semi Active :

A semi-active system has the ability to deflect the damping coefficient of damper but the direction of damping force is dependent on the relative velocity across the sprung and unsprung masses. The system consolidates a damper that can modulate its damping coefficient. Semi-active systems are classified as systems where the characteristics can be changed rapidly (typically in less than 100 milliseconds). The development of electro rheological (ER) and magneto rheological (MR) fluids has boosted research in the field of semi-active suspensions. Nowadays, the mentioned conflicting requirements cannot be met with passive suspension systems; therefore, the application of active and semi-active suspensions is mandatory. It was in early 1970s that active vehicle suspension systems were developed focusing on the optimization of trade off between ride quality and road handling. Semi-active suspension enables smooth changes of damper coefficient. It can be nearly as effective as fully active suspension in improving ride quality. Semi-active control devices potentially offer the reliability of passive devices, yet maintain the versatility and adaptability of fully active system. Magneto rheological damper is a good example of device for semi-active suspension. Active suspension contains the power controlled actuator located between the wheels and vehicle body, for instance linear electric motor or hydraulic servomechanism.

2.1.6. Passive Suspensions :

The damping value (C_s) of a passive damper is determined by the total orifice area (the number of hole) in the piston head.

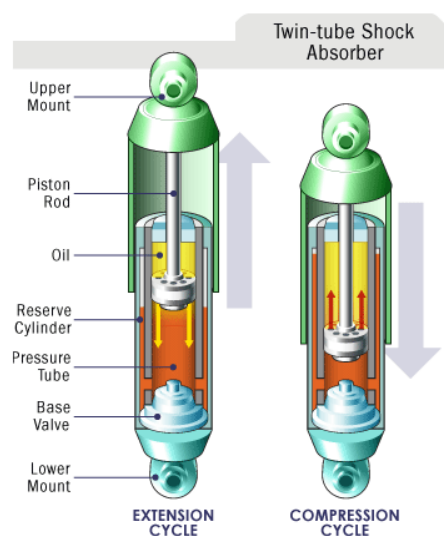


Fig-4: Passive type suspension

2.1.7. Comparison Between Active, Passive , Semi Active and Adaptive Suspension :

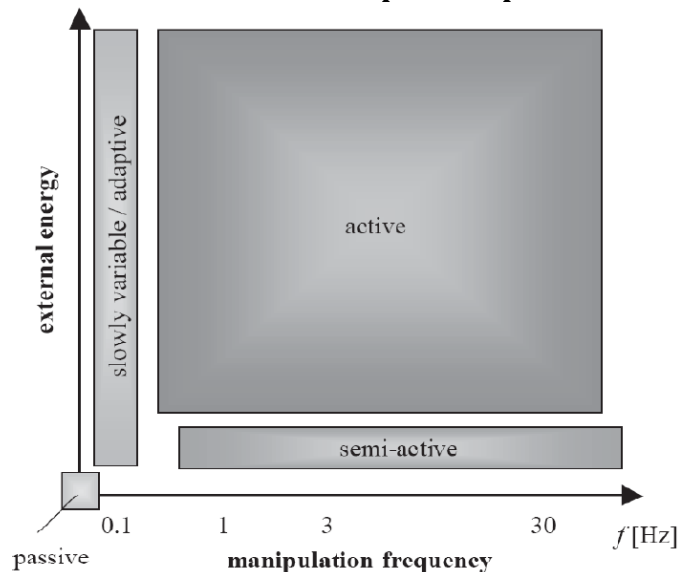


Fig-5: Comparison graph of active, passive, semi active and adaptive systems

The above diagram shows the conflict that automobile manufacturers face in their endeavor to improve drive safety and comfort as high – performing suspensions systems can and be expensive and complex actuation systems.

2.1.8. MR Fluid :

Magneto-rheological fluid is poised of oil and varying percentages of ferrous particles (20-50 microns in diameter) that have been coated with an anti-coagulant material. Deviating the magnetic field strength has the effect of changing the viscosity of the magneto rheological fluid.

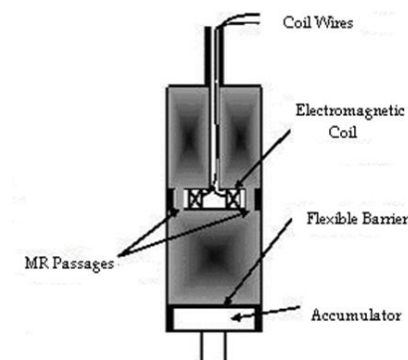


Fig-6: MR fluid based Semi-Active Suspension

2.1.9. Influence of Vehicle Parameters ¼ Car Simulation :

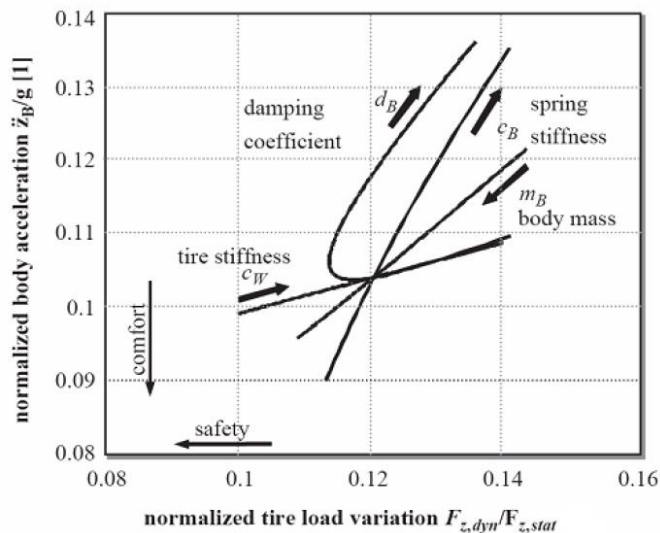


Fig-7: Graph between normalized tire load variations vs. body acceleration

From above diagram, the rigid setting of a passive suspension system is always a pact between comfort and safety for any given input set of road and a specific stress. Semi-active/ active suspension systems try to solve or least reduce this emulation.

2.1.10. OBJECTIVE OF SUSPENSION :

The objectives of suspension system are as follows:

- To prevent the road shocks from being transmitted to the vehicle components.
- To safeguard the resider from road shocks.
- To preserve the stability of the vehicle in pitching or rolling, while in motion.

2.1.11. Shock Absorber

Shock absorbers are hydraulic pump like devices that help to control the impact and recoil movement of the vehicle's springs and suspension. Along with equalizing out bumps and vibrations, the key role of the shock absorber is to ensure that the vehicle's tyre remain in contact with the road surface at all times, which results the safest control and braking response from the car.



Fig - 8: Mini Shock Absorbers

2.1.12. Types of Shock Absorbers

Shock Absorbers are of following types:

- Twin Tube : It has following sub types :
 - ✓ Basic Twin Tube
 - ✓ Twin Tube Gas Charged
 - ✓ Position Sensitive Damping
 - ✓ Acceleration Sensitive Damping
 - ✓ Coil over
- Monotube

2.1.13. Applications of Shock Absorbers :

Shock absorbers are an important component of automobile and motorcycle suspensions, aircraft landing gear, and the supports for many industrial machines. Large shock absorbers have also been used in structural engineering to reduce the susceptibility of structures to earthquake damage and resonance. A transverse mounted shock absorber, called a yaw damper, helps keep railcars from swinging extremely from side to side and are important in passenger railroads, commuter rail and rapid transit systems because they prevent railcars from damaging station platforms.



Fig – 9: An illustration of shock Absorber used in vehicles

2.1.14. Benefits of Shock Absorber :

- **Safety:** Main component of suspension system are shock absorbers. Thus, their major role in vehicle safety is to provide steering stability and complete vehicle safety. Worn out shockers lack the capacity required to control the car and add about twenty percentages to your vehicle’s stopping distance. This can seriously hazard the vehicle and safety of all the passengers in the car.
- **Stability:** Another important role of shock absorbers is stability. They increase the friction between car tyres and road enabling car stability on the road. If streets, highways and country roads were perfectly flat then shockers wouldn’t be necessary. But even recently paved roads have subtle flaws that apply forces to the wheel causing it to move up and down. Without shock absorbers, all vertical energy of wheels will be shifted to the frame of the vehicle. This can thus cause for the wheels to lose contact with the road surface for a moment and then, thanks to Newton’s gravity, slam back onto the road.
- **Comfort:** Comfort is the most common thing associated with shock absorbers. Since the invention of the first car, the challenge of enhancing passenger’s comfort was a major part of manufacturing process. That’s why absorbers were invented. Their job is to provide vehicle stability, is to ensure the comfort of all passengers. They reduce the magnitude of vibratory motions due to various road weaknesses to provide a smooth and comfortable ride.

3. CONCLUSIONS

From the above investigations and experimentations, we conclude that:

- Vehicle’s Suspension system is responsible for driving comfort and safety as the suspension carries

the vehicle body and transmits all the force between body and road.

- 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.

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BIOGRAPHIES



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