The necessity of providing suspension systems engineering essay

Suspension systems cope with the necessity of providing ride comfort and stability to a vehicle through uneven terrain. As such there are different types of suspension that cope with different demands using different methods.

As such, through the next few pages the different types of suspension and the different types of anti-roll systems will be explained.

There are several different suspension concepts in the market, each of them are unique in their own, hence strictly classifying them would require to mention each of the suspension used in the market for the different manufacturers, models and aftermarket options available. A more sensible way to classify suspension systems is by addressing the mechanism used to dampen the vehicle, such is the way used in this report to describe the available systems in the market.

Conventional suspension

A conventional suspension uses a spring to provide the stiffness of the suspension and a shock absorber to mitigate the vibration effect of the spring.

The most common conventional suspension is a coil-over; this is a coil spring over a damper. Although the coil-over is the most common type of conventional suspension, there are other alternatives such as using a leaf spring or in the case of a multi-link suspension, using the spring and the damper in two different places.

The main advantage of this system is that it is a cheap and cost efficient way to provide suspension.

On the other hand this system has to compromise between suspension stiffness for cornering and ride comfort.

Electric Suspension

Electric suspensions systems use electricity or magnets to dampen the vehicle. This system could entirely replace a conventional suspension, of work with a modified damper for that purpose.

The main advantage of this system is that is a progressive system that can provide more ride comfort and a stiffer suspension than a conventional depending on the driving situation.

The main disadvantage is that is more expensive and heavy than a conventional suspension.

Hydraulic Suspension

A hydraulic suspension uses a pressurized liquid to alter the suspension stiffness. As most non conventional suspensions, this system could entirely replace a conventional suspension or work with a modified conventional suspension.

As with most non conventional suspensions ride comfort and suspension stiffness is improved at the cost of a more expensive, complicated and heavier mechanism.

Hydro-Pneumatic Suspension

A hydro-pneumatic suspension is a suspension that uses the properties of gas to provide ride comfort (gas being less stiff than a conventional spring), and the properties of fluids to provide cornering abilities (liquids being nearly incompressible are stiffer than steel springs).

The main advantage of this system is that provides both a superior ride comfort at the same time that is able to provide an extremely stiff suspension for cornering. Another advantage of this system as well as all the other fluid suspensions (hydraulic and pneumatic suspensions) is that some of the current systems in the market are also capable of self-levelling the vehicle independently of the vehicle load and load distribution as well as being able of providing variable ride height.

So many advantages have also several drawbacks. Generally hydro-pneumatic suspensions are complicated and expensive kits that suffer from the problem of ride height drop, brake power and power steering performance drops if a failure in the suspension system were to happen (Actwin, n. d.).

Pneumatic Suspension

Pneumatic suspensions use gas (generally air, but sometimes compress and stored hydrogen or nitrogen is used) attempt to achieve the effects of a hydro-pneumatic suspension whist reducing the costs, weight and complication of the system.

Whist is true that these suspension systems achieve a good ride quality, it is not significantly better than a conventional suspension. One of the main problems of this type of suspension is that the system can be easily damaged if not installed and maintained properly as leakages can happen from the air bags, air lines or the compressor-drier system.

In-Wheel Suspension

In-wheel suspension is a new design that several companies are investigating in which all the suspension components are assembled either on the wheel rim or in the space inside the wheel rim.

Anti-Roll Systems

In the pursue of providing ride comfort at the same time as cornering performance the automotive industry has developed a wide range of anti-roll systems to reduce or counteract the rocking of the chassis during cornering due to the use of a soft suspension for ride control.

Although different companies and manufacturers have developed several systems all of them could be classified by the degree of interaction with the body roll.

Passive Anti-Roll

Passive anti-roll systems are systems that are permanently opposing body roll. The most common passive systems are anti-roll bars and torque arms, as such these systems whilst being fairly economic improve the cornering performance at the cost of reducing the ride comfort.

Semi-Active Anti-Roll

Semi-active anti-roll systems do not fully counteract body roll, instead by changing the way the suspension works (usually stiffening the suspension) they oppose the forces that generate body roll, therefore minimizing the rocking effects. This system manages to reduce greatly the body roll without compromising the ride quality, but needs an additional source of power to operate the system.

Active Anti-Roll

Active anti-roll systems operate not by opposing the rolling forces but instead by counteracting them. As such the body roll is more controlled than with a semi-active system and no compromise is made with ride comfort. The main disadvantages are that active systems are heavier, more complicated and expensive and have higher power consumption than semi-active anti-roll systems.

Additional Suspension Features

It is worth noting that some suspension types sometimes offer features such as self-levelling or ride height control. As such here some of the most common ones will be described

Self-levelling: the ability of a suspension to provide a flat (levelled) platform for the vehicle, independently of the vehicle load and load distribution.

Ride height control: the ability of a suspension to change the ground clearance.

Pitch control: the ability of a suspension to change the suspension settings to provide a flat platform to counteract the front dipping or raising due to braking and accelerating.

Yaw control: the ability of a suspension to combine self-levelling and pitch control to counteract the body movement whilst braking and cornering at the same time.

Suspension stiffness control: the ability to modify the firmness of a suspension to suit driver requirements, usually in a range between soft-comfort and hard-sporty

Depending of the manufacturer this systems can be fully integrated on the suspension of be independent but working in conjunction with the suspension

Main competitors in the market

BMW

BMW uses a dual suspension system; firstly the EDC (Electronic Damper Control) alters the suspension stiffness through electronically controlled dampers, and secondly an active roll stabilizer system called Dynamic Drive controls the body roll through a set of actuators that control the stabilizers (torque arms) is a similar fashion as the Range Rover system does. The BMW suspension system features self-levelling, pitch control and yaw control suspension (BMW, n. d.) (BMWUSA, n. d.) (Meeknet, n. d.).

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Figure BMW Active Roll Stabilization Actuator Diagram (BMWUSA, n. d.)

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Figure Electronic Damping Control Diagram (BMWUSA, n. d.)

Porsche

Porsche top of the range suspension for the Cayenne model offers air suspension combined with two other systems. Firstly the PASM (Porsche Active Suspension Management) system controls the stiffness and settings of each damper through management of the air suspension, and secondly the PDCC (Porsche Dynamic Chassis Control) system controls the body roll through a hydraulic system that operates the front and rear active anti-roll bars (torque arms). This suspension features pitch control, active anti-roll control, yaw control, ride height control and self-levelling (Porsche, n. d.) (Beechmontdata, n. d.).

Figure Porsche Active Suspension Management (PASM) Detail (Porsche, n. d.)

Mercedes-Benz

Mercedes-Benz uses the ABC (Active Body Control) active suspension that features pitch and roll control, self-levelling and ride height adjustable suspension achieved through servo actuated hydraulics. In this respect the system is similar to the current used in the Range Rover, but this system instead of using actuators, uses a modified suspension strut. The ABC suspension strut replaces the conventional dampers with electronically controlled plunger cylinder dampers whilst retaining the coil-over. The mechanism woks in a similar manner, the sensors and accelerometers

evaluate the situation and the oil pump send the pressure required to operate the suspension, but instead of using a single valve block and two actuators, the ABC system uses a front and rear servo-valves that in turn sent the oil to each of the four plunger cylinder dampers (Autoweb, n. d) (Worldcarfans, 1999).

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Figure Mercedes-Benz ABC System Layout (Worldcarfans, 1999)

MagneRide

MagneRide is a Magneto Rheological (magnetic and hydraulic) suspension developed by Delphi, and lately sold to BWI (Beijing West Industries) group.

The Magneto Rheological suspension is a semi-active suspension that alters the suspension stiffness of the fluid inside the dampers through electromagnets. This system although being a semi-active suspension is able to perform almost as well as an active suspension. Unlike a semi-active suspension the control of the suspension stiffness can be changed none linearly to the input response, hence instead for example instead of opposing the body roll, it can be counteracted by further increase of the suspension stiffness.

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Figure MagneRide Suspension (BIWGroup, n. d.)

This suspension has been fitted to some top of the range vehicles from the following companies Acura, Audi Buick, Cadillac, Corvette, Holden, and Ferrari (BIWGroup, n. d.).

Lexus

Lexus uses a suspension system called Active Stabilizer Suspension System that is the result of a joint venture between Toyota and Aisin Seiki Co. to develop an innovative suspension for Lexus (Toyota's luxury range of vehicles). The system is a fully electrically controlled active suspension system. The way it works is similar to the one currently used by Jaguar-Land Rover, but instead of using a hydraulic system, is using brushless motors geared and connected to the stabilizer bars (torque arms).

Toyota claims that this system is twenty times more energy efficient than a standard servo actuated hydraulic active suspension and its reaction time is also quicker, being considered to be within 20 milliseconds (Suzuki et all, 2006).

Figure Active Stabilizer Suspension System Outline (Suzuki et all, 2006)

PSA Peugeot Citroen group

The Hydractive system is a Citroen developed hydro-pneumatic suspension currently used by some cars from the PSA Peugeot Citroen group, in which the conventional coil springs and shock absorbers have been replaced by hydro-pneumatic shock absorbers. This system features self-levelling, ride height adjustment and automatically lowering the ride height above certain speed to reduce fuel consumption. Electronic controls avoid the suspension

dropping after the engine is switched off due to the lack of anti-roll bars. The PSA group also offers another package with the Hydractive suspension called Activa which is a yaw control mechanism incorporated in the suspension (Actwin, n. d.).

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Figure Citroen Hydractive Suspension Diagram (Actwin, n. d.)

Bose

Bose's active suspension is a cross between an in-wheel device and a conventional suspension, which is installed replacing a conventional coil-over spring damper (using its own damper and torsion arm to support the weight of the vehicle and minimize the suspension vibration). The way the mechanism works is by replacing the conventional shock absorbers and spring dampers by a single linear electromagnetic motor at each wheel. These electromagnetic motors are computer controlled to provide a soft suspension, but at the same time provide self-levelling, pitch control, yaw control and anti-roll (Bose, n. d.).

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Figure Bose's Active Suspension Diagram (Bose, n. d.)

Michelin:

Michelin has developed its own in-wheel suspension system. The system is a fully electrically operated suspension with a coil spring that is able to house

a wheel onboard traction and suspension system as shown in the picture below.

Figure Michelin Active Wheel Picture (Michelin, 2008)

This suspension system is a combined traction and suspension electrical system that as Michelin claims it could be used in a four wheel drive or a two wheel drive layout depending on power demands (Michelin, 2008).

Competitors Suspension Systems Summary

Company

Suspension Type

System Type

Anti-Roll Description

Self-Levelling Suspension

Ride Height Control

Land Rover

Coil-over

Active

Hydraulically controlled torque arms through a pump and two actuators

No

No

BMW

Electronically controlled dampers

Active

Hydraulically controlled torque arms through a pump and two actuators

Yes

No

Porsche

Air suspension

Active

Hydraulically controlled torque arms through a pump and two actuators

Yes

Yes

Mercedes-Benz

Hydraulic controlled plunger cylinder dampers

Active

Hydraulically controlled plunger cylinder dampers through a pump and a front and rear servo valves

Yes

Yes

MagneRide

Electrically controlled magneto rheological dampers

Semi-Active

Electromagnetically controlled damper fluid and damper stiffness

No

No

Lexus

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Active

Electrically controlled torque arms through brushless motors and reduction gears

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Peugeot-Citroen

Hydro-pneumatic

Active

Pneumatically controlled hydro-pneumatic suspension struts through an air pump and up to nine nitrogen to suspension fluid " sphere" chambers and front and rear anti-roll bars

Yes

Yes

Bose

Electromagnetic motors

Active

Four computer controlled electromagnetic motors replacing the conventional suspension struts

Yes

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