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ADVANCES IN AUTOMOBILE SUSPENSION SYSTEM

Siddhant Halnor
Sinhgad Institute of Technology and Science, Narhe, Pune.
siddhanthalnor@gmail.com

ABSTRACT

This study reviews the initial development of suspension system, necessity of suspension system for an automobile sector, concept of vibration, its causes, reasons and effects of vibrations on the automobile system. This review also includes important information on advanced suspension systems for automobiles, conventional and non-conventional suspension systems, a brief information about conventional suspension systems containing springs, shock absorbers, and dampers.

A brief introduction of some of the recent suspension systems used in the automobiles today is also elaborated like Bose suspension system which includes the use of the linear electromagnetic motor, double wishbone suspension system, Ferro-fluid or magneto-rheological dampers and Ford's control blade suspension system.

These suspension systems are now-a-days being included in to various automobiles to reduce the overall body motion and jarring vibrations and enhance comfort and control.

INTRODUCTION

Ancient military engineers used leaf springs in the form of bows to power their siege engines, the use of leaf springs in catapults was later refined and made to work years later. Springs were not only made of metal, a sturdy tree branch could be used as a spring, such as with a bow.

By the early 19th century most British horse carriages were equipped with springs; wooden springs in the case of light one-horse vehicles to avoid taxation and steel springs in larger vehicles. These were made of low-carbon steel and usually took the form of multiple layer leafsprings.[1]

The British steel springs were not well suited for use on America's rough roads and could even cause coaches to collapse if cornered too fast. The Abbot Downing Company of Concord, New Hampshire developed a system in the 1820s in which the bodies of stagecoaches were supported on leather straps called "thoroughbraces", which gave a swinging motion.

Automobiles emerged as self-propelled versions of horse drawn vehicles. However, horse drawn vehicles had been designed for relatively slow speeds and their suspension was not well suited to the higher speeds permitted by the internal combustion engine.

In 1901 Mors of Germany first fitted an automobile with shock absorbers and hence the era of development of suspension system started. FurtherLeyland used torsion bars in a suspension system. In 1922 independent front suspension was pioneered and became more common in mass market cars from 1933.[2]

NECESSITY OF SUSPENSION SYSTEMS:

Suspension is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels. Suspension systems serve a dual purpose – contributing to the car's roadholding/handling and braking for good active safety and driving pleasure, and keeping vehicle occupants comfortable and reasonably well isolated from road noise, bumps, and vibrations etc. These goals are generally at odds, so the tuning of suspensions involves finding the right compromise. It is important for the suspension to keep the road wheel in contact with the road surface as much as possible, because all the forces acting on the vehicle do so through the contact patches of the tires. The suspension also protects the vehicle itself and any cargo or luggage from damage and wear. The design of front and rear suspension of a car may be different.

For smooth running of an automobile on any type of road condition whether it is good or bad and any type of load carrying through vehicle, we are dependent on the suspensions.

When we are traveling on the road there is variation in the slope of the road and irregularities on the road due to which there are vibrations to an automobile and shocks due to bumps. These vibrations and shocks will lead to the danger for driver and the automobile. Thus to reduce the vibrations and the shocks produced by road conditions and to smoothen the motion of an automobile also to provide driver safety we look for the suspensions.

The basic suspension system contains two main parts springs and shock absorbers (Fig.1).Springs are of three types- coil springs, torsion bars and leaf springs. Coiled springs are nothing but the coiled torsion bars. Leaf springs are nothing but the layers of metal strips one above the other. These layers are called as leaves hence the name is leaf spring. Shock absorbers absorb the shocks. They dampen the vertical motion of our automobile caused because of driving on the rough surfaces or roads. They absorb large shocks due to bumps on road and prevent the chassis of automobile from getting the shocks. Shock absorbers also plant our vehicle to the road so that safe driving of an automobile is possible.

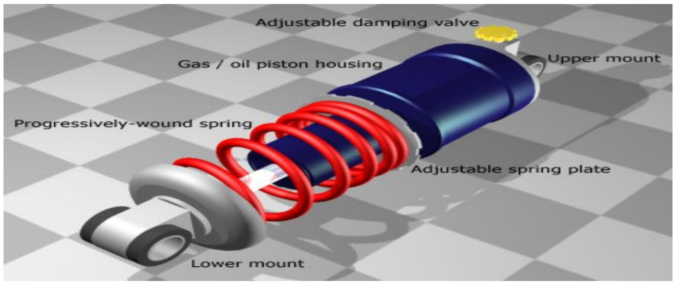

Figure 1: Main parts of basic suspension system

CAUSES OF VIBRATIONS THEIR REASONS AND EFFECTS:

During driving along the road we face the various problems like traffic, turns, irregularities, variations in the slope etc. which cause vibrations. But for safe driving of automobile we have to account of all these parameters and compensate them.

For example if the vehicle carrying the heavy load like bundles of metal strips, these vibrations causes damage to the parts of the content in that vehicle and may lead to the serious injuries and harm to the driver.

METHODS TO REDUCE THE VIBRATIONS:

There are different types of suspension systems that are used in the various automobiles. They are,

1. Conventional suspension systems
2. Non-conventional suspension systems

Conventional suspension systems:

In conventional suspensions, the conventional elements like rubber, springs, dampers, hydraulic fluid, pneumatic fluid are used. The types of conventional suspension systems are as follows,

A) Spring and shock absorber
B) Rubber suspension
C)Hydrolastic suspension
D) Hydragas suspension
E) Hydro pneumatic suspension

Non-conventional suspension systems:

Recent trends in suspension system are resembled with non-conventional suspension systems which contains various innovative suspensions designed to get the benefits to the driver and his safety.The few types of non-conventional suspension systems are as follows,

A) Bose suspension system
B) Ford control blade suspension
C) Double wishbone type suspension
D) Hydraulic suspension

Bose suspension system:

This is the latest innovation in suspension systems, invented by Bose also called aslinear electromagnetic suspension.In this instead of springs and shock absorbers on each corner of the car, a single liner electromagnetic motor and power amplifier can be used.

The Bose linear electromagnetic motors are used in a modified layout. The lower suspension arms and rack-and-pinion steering system attach to an aluminum engine cradle that bolts directly to the car body. Inside the linear electromagnetic motor are magnets and coils of wire. When electrical power is applied to the coils, the motor retracts and extends, creating motion between the wheel and car body. One of the big advantages of an electromagnetic approach is speed. The linear electromagnetic motor responds quickly (because of the use of electricity traveling at the speed of light) enough to counter the effects of bumps potholes and any other obstacles, thus allowing it to perform the actions previously reserved for shock absorbers.

In its second mode of operation, the system can be used to counter body roll by stiffening the suspension in corners. As well as these functions, it can also be used to raise and lower ride height dynamically. So you could drop the car down low for motorway cruising, but raise it upfor the pot-hole ridden city streets. .

The power amplifier delivers electrical power to the motor in response to signals from the control algorithms. These mathematical algorithms have been developed over 24 years of research. They operate by observing sensor measurements taken from around the car and sending commands to the power amps installed with each linear motor. The goal of the control algorithms is to allow the car to glide smoothly over roads and to eliminate roll and pitch during driving. .

The really smart thing about the power amps is that they are regenerative. So for example, when the suspension encounters a pothole, power is used to extend the motor and isolate the vehicle's occupants from the disturbance. On the far side of the pothole, the motor operates as a generator and returns power back through the amplifier. By doing this, the Bose system requires less than a third of the power of a typical vehicle's air conditioner system. Hence, it proves to be economical also.

Bose have also managed to package this little wonder of technology into a two-point harness - i.e. it basically needs two bolts to attach it to your vehicle and that's it. It's a pretty compact design, not much bigger than a normal shock absorber (Fig.2).

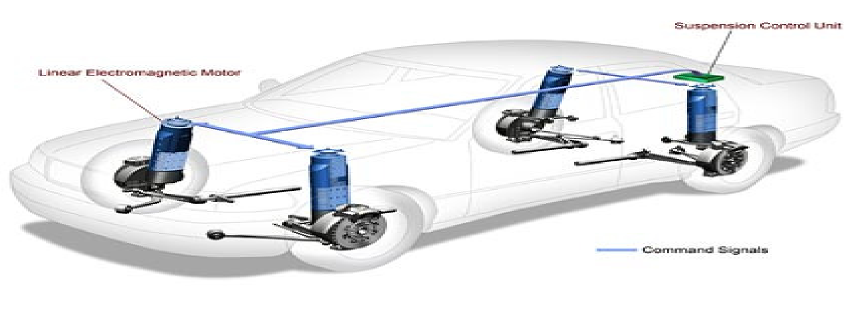

Figure 2: Bose suspension system

Ford Control Blade Suspension:

The development of this suspension started out itsaround 1998 in Ford of Australia. Control blade is basically an evolution of trailing-arm suspension. The primary purpose of Control Blade suspension is to increase the interior space available in the vehicle. Most suspension systems used in daily drivers have strut towers front and rear. In the front it's not really a problem, but in the rear it impedes on boot (or trunk) space. Control Blade system which in essence separates the shock absorber from the springs. To do this, Ford needed to use a trailing-arm type suspension so that they didn't have swing arms up under the wheel arches. The springs were shortened and moved inboard and underneath. In one variation, the shock absorbers still sit vertically but the space they take up now is hugely reduced because they no longer have the coil springs around the outside. In the second variation the shock absorber is a subminiature unit mounted inboard of the springs underneath the vehicle. The control blades themselves are basically the trailing arms which give lateral support and provide the vertical pivot point for the entire unit. .
It has the key function of promoting ride and reducing road noise transmission, while providing the freedom to let the lateral links define toe and camber by absorbing any rearward forces and allowing the rest of the suspension to do its job uninterrupted.This system has a much lower center of gravity than a McPherson strut. Lower Center of gravity in a vehicle is always a good thing. The geometry of the Control Blade system also provides significant 'anti-dive' under braking force, which means a the car body will dive less when you jump on the brakes which in turn translates into more well-behaved braking response. Lower C-of-G, less roll and less pitch during braking all add up to better handling, another function of this system is that they've separated the two basic functions of suspension. Only in the control blade system, it separates the springing support of the suspension from the shock reducing functions of the shock absorbers. There is one thing worth noting about this suspension system. Because the spring and shock are in different locations and because of the reduced or removed strut towers it makes it very difficult to bolt-on aftermarket suspension kits.

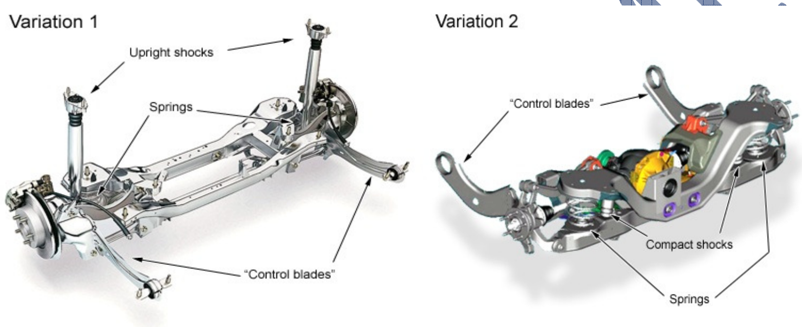

Figure 3: Variations of control blade suspension.

Double Wishbone Suspension Systems:

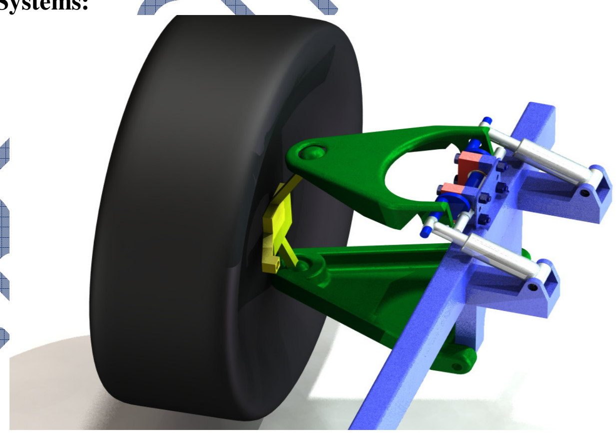

Figure 4:Double Wishbone Suspension Systems

The following three examples are all variations on the same theme.

Coil spring type 1: This is a type of double-A or double wishbone suspension. The wheel spindles are supported by an upper and lower 'A' shaped arm. In this type, the lower arm carries most of the load. If you look head-on at this type of system, we will find is that it's a very parallelogram system that allows the spindles to travel vertically up and down. When they do this, they also have a slight side-to-side motion caused by the arc that the wishbones describe around their pivot points. This side-to-side motion is known as scrub. Unless the links are infinitely long the scrub motion is always present. There are two other types of motion of the wheel relative to the body when the suspension particulates. The first and most important is a toe angle (steer angle). Steer and camber are the ones which wear tyres.(Fig.5).

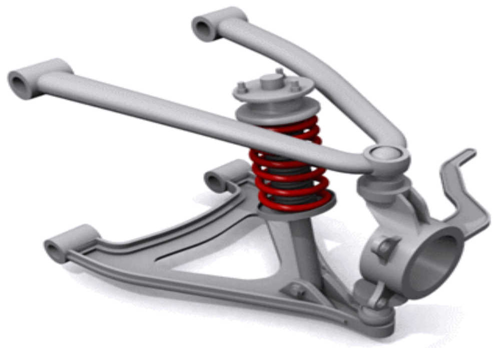

Figure 5: Coil spring type 1

Figure 6: Coil spring type 2

Coil spring type 2: This is also a type of double-A arm suspension although the lower arm in these systems can sometimes be replaced with a single solid arm (Fig.6). The only real difference between this and the previous system mentioned above is that the spring/shock combo is moved from between the arms to above the upper arm. This transfers the load-bearing capability of the suspension almost entirely to the upper arm and the spring mounts. The lower arm in this instance becomes a control arm. This particular type of system isn't so popular in cars as it takes up a lot room.

Multi-link suspension: This is the latest incarnation of the double wishbone system described above. It's currently being used in the Audi A8 and A4 amongst other cars. The basic principle of it is the same, but instead of solid upper and lower wishbones, each 'arm' of the wishbone is a separate item. These are joined at the top and bottom of the spindle thus forming the wishbone shape. The super-weird thing about this is that as the spindle turns for steering, it alters the geometry of the suspension by torturing all four suspension arms. They have complex pivot systems designed to allow this to happen (Fig.7). Car manufacturers claim that this system gives even better road-holding properties, because all the various joints make the suspension almost infinitely adjustable. There are a lot of variations on this theme.

Figure 7: Multi-link suspension

Hydraulic Suspension:

Hydraulic suspension also called as Ferro fluid or Magneto-rheological Fluid dampers - Audi Magnetic Ride is a totally new form of damping technology developed. The Audi system is a continuously adaptive system - i.e. it's a closed feedback loop that can react to changes both in the road surface and the gear-changes (front-to-back weight shift) within milliseconds. Well, the dampers in the Audi system are not filled with our regular old shock absorber oil. They're filled with magneto-rheological fluid. This is synthetic hydrocarbon oil containing subminiature magnetic particles. When a voltage is applied to a coil inside the damper piston, it creates a magnetic field. Inside the magnetic field, all the magnetic particles in the oil change alignment in microseconds to lie predominantly across the damper. Because the damper is trying to squeeze oil up and down through the flow channels, having the particles lined up transverse to this motion makes the oil 'stiffer'. Stiffer oil flows less, which stiffens up the suspension. The Audi system has a centralized control unit which sends signals to the coils on each damper. Hooked up to complex force and acceleration sensing gauges, the control unit constantly analyses what's going on with the car and adjusts the damping settings accordingly. Because there are no moving parts - no valves to open or close - the system reacts within microseconds; far quicker than any other active suspension technology on the market today. And because the amount of voltage applied to the coils can be varied nearly infinitely, the dampers have a similarly near-infinite number of settings. The power usage for each strut is around 5Watts, and the entire thing takes up no more room than a regular coil-over-coil-unit.

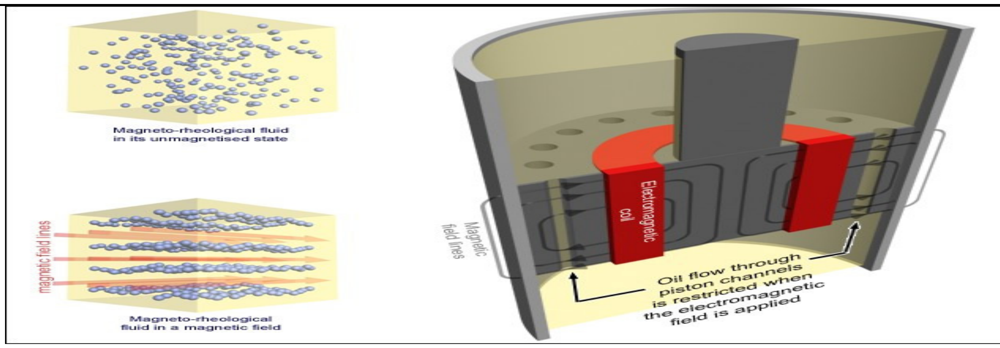

Figure 8: Magnetized vs. unmagnetised ferrofluid and cutaway of the piston assembly in a Magnetic ride-type damper

CONCLUSION:

The conventional suspension systems used nowadays in many automobiles systems reduce the vibrations of vehicle but they do not respond quickly to the road conditions. Advanced suspension systems involve the use of electrical sensors, hydraulic fluids, magnetic principles etc.

The Bose suspension system working on electromagnetic principles gives a rapid and smooth operation of the suspension with safety because of the fact that due to the changes in the electric current there is spontaneous change in the magnetic flux of the system. The Ford Control Blade suspension system has progressed in achieving low center of gravity and it also provides anti-dive under braking forces.

The Double wishbone type suspension system is a latest and very effective suspension type in which its arms or lobes can be adjusted according to the motion of the spindle of wheel.

In a hydraulic suspension system hydraulic fluid is the most important part. In this type the change in road condition is related to compression and expansion of hydraulic fluid i.e. signal is passed to the fluid and fluid compresses for big patches along the road and it expands and come to original equilibrium position when the road is smooth.

Thus from the above study it is concluded that the advanced suspension systems are more safe and they give effective as well as quick response to the various road conditions such as speed breakers,variation in slopes, turns, traffic, patches etc. Thus these are used in most of the new versions of automobiles.

REFERENCES:

[1] Kripal Singh, Automobile Engineering
[2] Car Bibles, The Car Suspension Bible.htm
[3] Narang, Automobile engineering
[4] Hydro pneumatic suspension - Wikipedia, the free encyclopedia.htm
[5] https://www.google.co.in
[6] Nouby M Ghazaly,IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) 10/2014; 11(5):19-25.