VIBRATION REDUCTION IN AUTOMOBILES USING ELECTROMAGNETIC SUSPENSION SYSTEM

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ABSTRACT

Introducing the technology of ‘Electromagnetic Suspension System’ which replaces the vehicle suspension system with electromagnets. It could also replace the hydraulic and pneumatic suspensions with the electromagnetic suspension. This system consists of two electromagnets placed inside the cylinder for the purpose of suspension. One electromagnet could be fixed and the other is made to be movable. For the purpose of varying the resistance, a rheostat is introduced. The current is varied by the rheostat. There is an additional attachment done to the one end of the rheostat. A strong spring is attached to the movable end of the rheostat for it comes back to its original position. A connection is made from the rheostat to the axle of the wheel by a rod. This rod helps the rheostat to vary the current. So when there is a variation in current, there is a repulsive force between the electromagnets that leads to the upward and the downward movement of the wheel based on the current flow and that is done with the help of the rheostat and this will allow the wheels to move up and down.

Keywords: Electromagnets, Rheostat, Suspension system, Electromagnetic force.


1. INTRODUCTION

Suspension is a general term given to the damping devices such as springs and shock absorbers which is usually connected to a vehicle and acts as a mediator between the wheel and the vehicle body in an automobile. These systems also serve a dual purpose of the vehicle safety also the breaking systems for good and driving pleasure. They keep the vehicle passengers comfortable and well isolated from the road vibrations. It is necessary for the suspension to keep the road in contact with the wheel because all the vibrations travel through the suspension systems to the vehicle body.¹ The front wheel suspension and the rear wheel
suspension may vary based on the vehicle type. The suspension also designed to protect the vehicle and also any cargo and luggage from getting damaged. The suspension system of any vehicle will vary based on its type and capacity. The heavy loaded vehicles are fixed with heavier springs according to its bearing capacity to compensate the load or else it may collapse the vehicle. In extreme conditions, the heavy springs are used for performance applications. Suspension systems can be classified into two categories, one is dependent and the other independent based on their vehicle type. These terms refer to the ability of opposite wheels to move independently of each other.

A simple cart or driven axle are basically the dependent suspension systems that holds the wheel parallel to one other and are also perpendicular to the axle. When the camber of one wheel is changed, the other wheel opposite to the camber also gets changed. The wheels could be rigidly connected together by the De Dion Suspension system. The wheel rises and falls without affecting the other wheel of their own by the independent suspension process. The sway bars where the wheels are linked are still classified as independent. The last type could be called as semi dependent suspension. In semi dependent suspension the motion of one wheel gets affected then the position of the other wheel also gets affected but there is no rigid attachment with each other. The magnetic field is produced by the flow of electrons from magnets and such type of devices can be called as electromagnets. When there is a cut off in the flow of electrons or when the current reduces, there will be a loss in the magnetic field. Devices such as generators, speakers, motors, hard disks, etc. are some of the components where the electromagnets are commonly used. In the case of industrial applications, electromagnets are very much used for industrial lifting of heavy and scrap materials.

Here we bring in the use of electromagnets with the help of a rheostat to introduce ‘Electromagnetic Suspension System’ that would replace every other suspension systems providing a very easy and comfortable drive. This suspension is based on the repulsive force that is obtained by the electromagnets. It works on the principle of ‘Faraday’s Law of Induction’ which states -The induced electromotive force in any closed circuit is equal to the time rate of change of the magnetic flux through the circuit or The EMF generated is proportional to the rate of change of magnetic flux. Electromagnetic suspension systems could be used in automobiles based on their requirement. These electromagnetic suspension systems provide much comfort and safety when compared to other conventional suspension systems. This also has more efficiency to the vehicle and also guarantees zero percent vibration to the body of the vehicle. Since it gives the maximum comfort nature to the people inside the vehicle, ‘Electromagnetic Suspension System’ will be the most commonly used suspension system in near future.

The vertical energy from all the wheels are transferred to the frame in the same direction without an intervening. The wheels may lose contact with the road completely in such situations. Due to gravitational force the wheels can come back to the original position after the vibrations. The device’s main aim is to the energy that is vertically accelerated over the wheel allowing the wheel to be undisturbed even when there may be vibrations on road. The study of the forces at work over a moving vehicle could be called as vehicle dynamics, and all you need to understand is that some of these concepts in order to appreciate why a suspension is necessary at the first place. Most automobile engineers consider the dynamics of a moving vehicle in two perspectives, Ride a vehicles ability to smooth out a bumpy road and also Handling a vehicle’ s ability to safely accelerate, brake and corner. When roads are perfectly flat, there won’t be any use of this type of suspension systems but roads being flat is totally impossible which lead us for the mandatory use of these suspension systems and these type of electromagnetic suspension systems work on the principle of faradays law of induction.
2. MATERIALS AND METHODOLOGY

The suspension system in many contemporary vehicles could be comprised of a front and rear suspension modules that are bolt to the inner side of an automobile. The Bose suspensions uses this case by making a new type of front and rear suspension modules. The research team has tried to utilize this Bose suspensions with a minimum changed and fit the equipment over to the vehicle. Bose's front suspension modules use a modified MacPherson strut layout and the rear suspension modules use a double-wishbone linkage to link the wheels to the automobile body through an electromagnet. Torsion springs could be used to support the weight of the vehicle and also to balance the load. The Bose system uses a linear electromagnetic motors at each wheel so that it could give a complete and separate control for each wheel. The LEM has the ability to extend and retract with much greater speed when compared to that of hydraulic damper. These dampers take just few milliseconds to react and absorbs the vibrations with very good efficiency. These fast reflections and response and also the precise movement allows the wheel motion to be so finely controlled that the body of the car could remain at the same level neglecting the vibrations. The Linear electromagnets may also counter act at the motion of a vehicle body even when accelerating, braking and cornering.

![Figure 2.1 Experimental setup of electromagnetic suspension system](image)

This system may provide a dynamic and also high-capacity suspension which offers high class ride quality. In this way the resulting system does not possess any frequency and associated dynamic instabilities, which need to be suppressed through extensive damping in conventional suspension systems.

Remanence, coercively and curie temperature are most commonly used property to compare with permanent magnets. Remanence is the property which measures the strength of the magnetic field, coercively is the property which measures the materials resistance to get demagnetized and the curie temperature is nothing but the property of the material at which temperature it loses its magnetism. Usually the Rare earth materials will have high reminisce, coercively, but lower Curie temperature than other types. (eg Neodymium)

If a soft iron rod which can be called as core is placed inside a solenoid, then the strength of the magnetic field becomes very large because the iron ore is magnetized due to induction. The core of the electromagnet can be of soft iron because soft iron loses all of its magnetism
when current in the coil is switched off. Steel could not be used in electromagnets, because when the flow of electrons is cut it the current it doesn’t not lose all its magnetism but acts as a permanent magnet.

2.1 Force between electromagnets

\[ F = \mu_0 m_1 m_2 / (3.14 r^2) \]

Where, \( F \) is the Force exerted by magnetic field, \( \mu_0 \) is the Permeability of free space (or air), \( m_1 \) is the Pole strength of the first electromagnet, \( m_2 \) is the Pole strength of the second electromagnet and \( r \) is the Distance between the poles of two electromagnets.

The magnetic force component of the Lorentz force is responsible for motional electromotive force or can also be called as motivational electromagnetic force, the phenomenon underlying many electrical generators. When a conductor moves through a magnetic-field, the electromagnetic force tries to push the electrons through the wire, resulting in EMF (electromagnetic force). The term motional electromagnetic force could be applied at this situation, since the EMF is caused due to the motion of the wires or by similar materials. In electrical generators, the magnets move, while the conductors do not. In this case, the EMF is due to the electric force term in the Lorentz Force equation. The electric field in question is created by the changing magnetic field, resulting in an induced EMF, as described by the Maxwell-Faraday equation. Both of these EMFs, despite their different origins, can be described by the same equation, namely, the EMF is the rate of change of magnetic flux through the wire. In fact, the electric and magnetic fields are different faces of the same electromagnetic field, which moves from one inertial frame to the other, the solenoid vector field portion may vary in whole or even it may vary as a part to a B-field or even vice versa of the Electric field.

2.2 Description of electromagnetic suspension system

The Electromagnets which are placed in the cylinder and connected to the wheels out of which one is fixed and the other movable which are placed in the top and bottom of the cylinder respectively. These serve the purpose of suspension replacing the pneumatic and hydraulic suspensions. The Rheostat which varies the current and resistance is attached to the chassis of the vehicle. One end of the Rheostat will be linked to axle of the wheel and the other to the movable electromagnet through a battery. Varying the current and the resistance with the help of rheostat, the power of the electromagnet also varies. This would help the chassis to move up and down over the dip with very less vibration. The Rheostat comes back to the original position with the help of the spring.

2.3 Working of electromagnetic suspension system

1. Here, a speed breaker is considered which comes ahead when the vehicle is moving at a particular speed. When the wheel hits the speed breaker, there will be an upward force acting upon the wheel.

2. There is a rod that is connected or linked from the axle of the wheel to the rheostat; the rod helps the rheostat to vary the resistance and current.

3. This rheostat is also linked to electromagnets for the suspension system. Now as the current varies, the repulsion force between the electromagnets also varies due to the variation in current.

4. In this way the wheel moves in and out of a dip without jostling of the car body.
3. RESULT AND DISCUSSION

3.1 Designing the suspension

Wheel is drawn using the circle command and extruded for the dimensions

a) Wheel thickness – 210 mm  
b) Outer diameter – 550 mm  
c) Inner diameter – 50 mm

Rim is drawn using line, arc command and the unnecessary parts are removed using remove material command.

Edges of the Rim are filleted using round command.

Figure 3.1.2 Design of tyre, disc brake, hub and cv joint of a car
Tyre is drawn using the revolve command with dimensions
  a. Thickness – 50mm
  b. Breadth – 216mm

Disc brake is drawn using revolve command with dimensions
  a. Diameter – 252mm
  b. Thickness – 25mm

CV joint is drawn using the extrude command for one side and is mirrored on the other side using the mirror command.
  A shaft is drawn using the circle command and then extruded and is attached to the CV joint.
  The suspension rod is attached to the CV joint.
  The suspension cylinder is drawn using extrude command for the dimensions
    a. Height – 420mm
    b. Outer diameter – 190mm
    c. Inner diameter – 150mm

Electromagnets are drawn using the extrude command for the dimensions
  a. Thickness – 40mm, Diameter – 150mm

3.2 STRESS ANALYSIS

Material selection
  b. Cylinder – Aluminium
  c. Electromagnets – Iron Core
  d. Rod – Cast Iron

Figure 3.2.1 Meshing of electromagnetic suspension system
Boundary condition

Aluminium: Density: 2.7 gm/cm^3
Young’s Modulus: 70 GPa
Poison Ratio: 0.35

Iron Core: Density: 7.874 gm/cm^3
Young’s Modulus: 211GPa
Poison Ratio: 0.29

Cast Iron: Density: 6800 Kg/m^3
Young’s Modulus: 17 *10^4 N/mm^2
Poison Ratio: 0.21

Figure 3.2.2 Stress analysis of electromagnets suspension system

The maximum stress that was obtained after the analysis the electromagnetic suspension was about 130.307 N/mm^2. Deployable structures are due to their large and light built very flexible. Also their structural properties often change considerably during the shape transformation. That makes it difficult for the suspension system to carry exactly the weight of the structure throughout the entire range of motion without imposing extraneous constraints and hence producing internal stresses which distort the static and dynamic properties and therefore the deployment behavior of the structure. Adjustable support systems provide the ability to adapt for the changing structural configuration during deployment. The max stress obtained after the analysis of the electromagnets is 130.307N/mm^2.

4. CONCLUSION

The process of introducing a new technology to the world of automobiles in the form of ‘electromagnetic suspension system’ came through different stages. The principle involved in our concept of electromagnetic suspension system was, the repulsive movement of electro magnets was controlled by the rheostat which works on the basis of ohm’s law which states that resistance is inversely proportional to the current. So as the vehicle goes over a dip, the
rheostat will control the movement of electromagnets to move up and down without jostling of the car body.

At first we came up with the design of the experimental setup of electromagnetic suspension system using the paint software. It consisted of mainly electromagnets, suspension cylinder arrangement with a piston, and a rheostat. Then the whole model was designed with assumed dimensions for wheel, tyre, hub, cv joint, electromagnets, suspension cylinder, piston, axle and rheostat using the pro-engineer software. The design parts were then imported to Ansys software to analyze the various parameters like stress, strain, load bearing capacity, and repulsive forces of electromagnets. It was checked under different boundary conditions for different materials assigned for different parts of the electromagnetic suspension system. It was found that our design was safe under every conditions assigned to different parts of the system.

The prototype was then made with the help of rare earth magnets – neodymium magnets of each 25 mm in diameter that has 4000 gauss power each. We made use of a wheel of the 2-wheeler vehicle and the magnets were placed inside the suspension cylinder with like poles faced to each magnets so as to show the repulsion force. We find it a huge success even with just the prototype. Thus, the electromagnetic suspension system will be a real success in the market when manufactured with the correct dimensions of any 4-wheeled vehicles or even 2-wheeled vehicles. Apart from the suspension, the energy used can be regenerated back to the battery. These suspensions will prevent the damages that can be caused due to the bottoming and lifting of the wheel as it is free from vibrations. Hence bringing in the use of Electromagnetic suspension system will give you an easy and a very comfortable and safe drive.

REFERENCES


