DESIGN AND FABRICATION OF NEODYMIUM MAGNETIC SHOCK ABSORBER

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ABSTRACT

Magnetic suspension is the technology for supporting an object without contact by means of a magnetic force. Magnetic suspension systems have many advantages, which are the realization of high speed due to no friction, the applications in clean rooms because of no generation of the dirt, and the applications in the cosmos because of the lubrication free. So far, many kinds of magnetic levitation systems have been proposed and developed. These magnetic levitation systems use various methods to control the suspension force. Two types of systems are electromagnetic suspension systems, which control the coil current so as to change the magnetic force in order to levitate an object stably and mechanical magnetic suspension systems, which use permanent magnets and control the magnetic reluctance so as to vary the suspension force in order to achieve stable suspension. This thesis concentrates on the mechanism magnetic suspension systems, and proposes a zero power control method for a mechanism magnetic suspension system, a noncontact spinning system using permanent magnets and rotary actuators, a novel magnetic suspension system using the variable flux path control method, and the simultaneous suspension of two iron balls using the variable flux path control mechanism. Shock absorber will not absorb road shocks efficiently if the suspension springs are highly rigid. They will be continuous vibrated for a long time if the springs are sufficiently flexible. To overcome this difficulty, a system having compromise between flexibility and stiffness should be used. Shock absorbers are used as a part of the suspension system. They provide more resistance to the motion of the spring and road wheel in order to damp out vibrations.

Keywords: *Magnetic suspension, flux and Neodymium.*

INTRODUCTION

This project is based on suspension system of two wheelers which were formally depending upon spring type, hydraulic and pneumatic suspension systems. This report gives information about magnetic suspension system and the magnetic suspension system is turning out to be the new option to these conventional suspension systems. The aim of this project is to study and investigate the response of system, when it is subjected to road surface irregularities with the hope that it would help automobile industry. This project presents design, construction and working of magnetic suspension system. This system uses magnets and spring as passive dampers, which are used to reduce displacement and acceleration of sprung mass in order to improve ride comfort. By using this type of absorber we can absorb the more number of shocks and variations are absorbed with more accuracy. This type of Suspension has no problem of leakage of oil like hydraulic shock absorber. Also this has less maintenance than other types of shock absorber that we can made this type of shock absorber for the efficient work of vehicle and for reducing the maintained cost of vehicle.

Basic twin-tube: Also known as a "two-tube" shock absorber, this device consists of two nested cylindrical tubes, an inner tube that is called the "working tube" or the "pressure tube", and an outer tube called the "reserve tube". At the bottom of the device on the inside is a compression valve or base valve. When the piston is forced up or down by bumps in the road, hydraulic fluid moves between different chambers via small holes or "orifices" in the piston and via the valve, converting the "shock" energy into heat which must then be dissipated.

Twin-tube gas charged: Variously known as a "gas cell two-tube" or similarly-named design, this variation represented a significant advancement over the basic twin-tube form. Its overall structure is very similar to the twin-tube, but a low-pressure charge of nitrogen gas is added to the reserve tube. The result of this alteration is a dramatic reduction in "foaming" or "aeration", the undesirable outcome of a twin-tube overheating and failing which presents as foaming hydraulic fluid dripping out of the assembly. Twin-tube gas charged shock absorbers represent the vast majority of original modern vehicle suspensions installations.

Position sensitive damping: Often abbreviated simply as "PSD", this design is another evolution of the twin-tube shock. In a PSD shock absorber, which still consists of two nested tubes and still contains nitrogen gas, a set of grooves has been added to the pressure tube. These grooves allow the piston to move relatively freely in the middle range of travel (i.e., the most common street or highway use, called by engineers the "comfort zone") and to move with significantly less freedom in response to shifts to more irregular surfaces when upward and downward movement of the piston starts to occur with greater intensity (i.e., on bumpy sections of roads— the stiffening gives the driver greater control of movement over the vehicle so its range on either side of the comfort zone is called the "control zone"). This advance allowed car designers to make a shock absorber tailored to specific makes and models of vehicles and to take into account a given vehicle's size and weight, its maneuverability, its horsepower, etc. in creating a correspondingly effective shock.

Acceleration sensitive damping: The next phase in shock absorber evolution was the development of a shock absorber that could sense and respond to not just situational changes from "bumpy" to "smooth" but to individual bumps in the road in a near instantaneous reaction. This was achieved through a change in the design of the compression valve, and has been termed "acceleration sensitive damping" or "ASD". Not only does this result in a complete disappearance of the "comfort vs. control" tradeoff, it also reduced pitch during vehicle braking and roll during turns. However, ASD shocks are usually only available as aftermarket changes to a vehicle and are only available from a limited number of manufacturers.

Coilover: Coilover shock absorbers are usually a kind of twin-tube gas charged shock absorber inside the helical road spring. They are common on motorcycle and scooter rear suspensions, and widely used on front and rear suspensions in cars.

MATERIALS AND METHODS

- Neodymium Magnets
- Spring
- Shaft
- Sealants

Table 1. Properties of Neodymium

Property	**Neodymium**
Remanence(T)	1-1.3
Coercivity(MA/m)	0.875-1.99
Relative permeability	1.05
Temperature coefficient of remanence(%K)	-0.12

Temperature coefficient of coercivity(%K)	-0.55-0.65
Curie temperature(^{0}C)	320
Density(g/cm^3)	7.3-7.5
Flexural strength(N/mm^2)	250
Compressive strength(N/mm^2)	1110
Vickers hardness(HV)	550-650

Springs are elastic bodies (generally metal) that canbe twisted, pulled, or stretched by some force. They canreturn to their original shape when the force is released. In other words it is also termed as a resilient member.

Drive shaft, driveshaft, driving shaft, propeller shaft (prop shaft), or Cardan shaft is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them.As torque carriers, drive shafts are subject to torsion and shear stress, equivalent to the difference between the input torque and the load. They must therefore be strong enough to bear the stress, whilst avoiding too much additional weight as that would in turn increase their inertia.

Design Components

Design of Spring

Length =82mm

Thickness =1.5mm

Number of turns =11

Outer diameter of the spring(Do) =25mm

Wire diameter(d) =2.5mm

Therefor Inner diameter(Di) =25-5

=20mm

Assume, the shear stress	=600N/mm^2 (from design data book)
Spring index	=Do/d
	=25/2.5
	=10

For this spring index, (from data book)

Wahl's correction factor of spring	=1.18
Load holding by spring, P	=σ * K

Where σ is the shear stress and

K is the Wahl's correction factor of spring

ThereforP	=600/1.18
	=508.4N

Design of Magnet

Weight Vehicle Body =15kg	= 147N
Weight of Person Sitting on Vehicle = 60kg	=588N

Total Load = Weight of Vehicle Body + Weight of Person Sitting on Vehicle	=147+588
TotalLoad =147+588	=735 N
Rear Suspension = 65percentage of 735 N	=441N
Considering Dynamic Loads Double (W) 441 N	=882 N
For Single Shock Absorber Weight(W/2)	=441 N

Taking Factor of Safety	= 1.2
So, Design Load	=621.3N

Magnetic Power per Unit Area =2

So, Area Required for Suspension Of 300kg load

2 = 621.3/A

A = 310.65

d = 48.1mm=50mm

d = 50mm

Diameter of magnet (d) = 50mm

The unit of two circular magnets and a rod (straight cylindrical rod which can be used as axle). One magnet is attached at the bottom of the rod is the base magnet. The other magnet is free with a float and has the similar pole placed towards the base magnet. The similarity of poles creates repulsion and a certain distance is maintained. As per load condition, the floating magnet moves and close the gap until the magnetic repulsion is strong enough to create the damping action. In this a shock absorber without spring working on the basic law of magnets (fig1)

If the suspension springs are strong enough, they will absorb road shocks efficiently, and they are flexible enough, they will continuous to vibrate to long time even after the bump is passed. When vehicle wheel strikes a bump, the spring is compressed enough and little vertical up-ward motion is transferred to the frame. When the wheel comes down from road bump, the spring expands very rapidly. If this rebound is not controlled the spring starts vibrate heavily. To control this vibration, at the shock absorber is used in the suspension system. Similarly, when a wheel falls over a hole, a spring expands and is unable to take full vehicle load. The shock absorber takes part of this load (fig 2).

In case of leaf spring suspension system, the friction between the leaves provide the damping effect. But the because of the uncertainly of the lubrication condition, the amount of vibration also varies and hence damping characteristic do not remain constant. Therefore, additional damping provided by means of dampers or shock absorber. Frequently, shock absorber housing is linked to the frame across the member and the shock absorber arm is connected to the spring, axle or suspension control arm.

Magnets suspension worked on magnetic repulsion force between die poles in vertical pass across a bump condition that time force acting lower side of magnet of the piston and bottom side magnet of the cylinder. The shock absorber due to repulsive force between piston bottom side magnet cylinder bottom side magnets. They are reflected at a certain distance as per load that we are mention. The gap between two magnets is about 1cm apart. At the jerk condition the piston moves upward side of the upper side magnet again the repulsive force between upper sides two magnets are repel to each other. And the piston returns its original position.i.e. center of cylinder. This suspension system easily absorbs road shock, damping, vibration to avoiding tear and wear.

EXPERIMENTAL SETUP

One magnet is fixed with piston. Another one is movable, which is connected with rod. With magnets are replaced by air. Our magnetic shock absorber works on the basic principle of magnet that “opposite poles attract each other and same poles repels each other”. In this both magnets are facing same poles (both magnets are placed facing north and north or south and south). Both magnets are same pole. When the rod moves inside the piston movable magnet move towards the fixed magnet. Since both magnets are of same pole repulsion force is created between the magnets. So the movable magnet opposes the rod action and moves the rod up. The piston or cylinder is made up of non-magnetic material. The non-magnetic material will hold the magnet in both the sides. By using this type of shock absorbers the suspension will be more and the impact of vibration is very less compared with the spring loaded shock absorbers. Thus the magnetic shock absorber works. When the weight of the vehicle increases or vehicle climbs irregular surface, the wheel goes upwards and shock absorber is compressed, at this time the piston moves downwards. The magnets are made closer to each other, due to the increase of weight, the piston rod containing magnet is made to compress to certain extent (6).

At the same time, the stainless steel spring provided is freely inside the shock absorber. The additionalsupport for magnetic shock absorber is provided by a helical coil spring, which was compressed at this stage. So the shocks and vibrations are prevented. When the weight of the vehicle is decreased or it returns to its original position, the shock absorber gets expanded. In this position the piston moves from the bottom to top due to the magnetic flux power of the magnet. The stainless steel spring provided inside the shock absorber made the magnets inside the piston rod to return to its original position slowly. The coil spring return to its original position. Thusthe magnetic shock absorber absorbs the shock and vibrations produced while running a vehicle on a irregular road surface (fig 3).

RESULT AND DISCUSSION

The neodymium is brought and the magnetic shock absorber is fabricated with the necessary dimensions. The same poles of the magnet got repelled to each other producing a repulsionforce. Thus the shock produced on the vehicle is absorbed by the this (fig 4-6).

we have the exact equation to find the repulsive force between two identical magnet, having same shape, size, magnetic force (fig 7). For two cylindrical magnets with radius R, and height *h*, with magnetic dipole aligned and the distance between them greater than a certain limit, the force can be well approximated (even at distances of the order of *h*) by,

$$F(X) = \frac{\pi\mu 0}{4} R^4 \left[\frac{1}{X^2} + \frac{1}{(1+2h)^2} - \frac{2}{(x+h)^2}\right]$$

Radius of the magnet R = 2.5 cm

Permeability od free space, μ =4π*10^{-7}

Height of the magnet = 1.25 cm

At normal conditions the magnet rests at distance which is equal to distance between two magnets and the minimum distance when it come during shock is 3cm. So there is a maximum and minimum force, between these repulsion force varies.

Therefor repulsive force,

$$F(X) = \frac{\pi\mu 0}{4} R^4 \left[\frac{1}{X^2} + \frac{1}{(1+2h)^2} - \frac{2}{(x+h)^2}\right]$$

When x = x1

That is x = 3cm, Repulsive force will be maximum

$F_{max} = 4.23*10^{-6}$

When x = x2

That is x = 8.2cm

$F_{min}= 4.571*10^{-5}$

Calculation Of Deflection

To calculate the deflection the following steps has to be done.

- Mark the length of the shaft before loading.
- Put a load of 60kg on the top of circular disc.
- Now measure the length of the shaft to know how far does the magnets move.
- Take the reading and note it down.
- Repeat this for the same load and note it down.

Length of the shaft	= 8.2cm
Load applied	=60kg
Final length of shaft	=4.8cm
Deflection	= Initial length – final length
	=3.4cm

CONCLUSION

Magnetic suspension system mainly summarised on the use of permanent magnets in order to overcome the disadvantages of conventional suspension systems like –less life, frequent maintenance and less durability. More importantly magnetic suspension system can be used as an option to conventional suspension system with no doubt. Here in our project we designed a magnetic suspension system for a two wheeler well known as shock absorbers. The design of this magnetic system mainly included few steps like selecting proper materials for the components of the system then designing the dimensions of component and system by stress and load. This project mainly started with the literature review of magnetic suspension system which mainly discussed with the drawbacks of conventional suspension system and advantages of using magnetic suspension system at the same place. The project introduction included the working principle of shock absorbers, objectives for the same, The project also contains the classification of suspension system. Then the project concentrated on the construction, working principle of magnetic suspension system. The material selection was also included in order to design the system. This project included the design calculations afterwards.

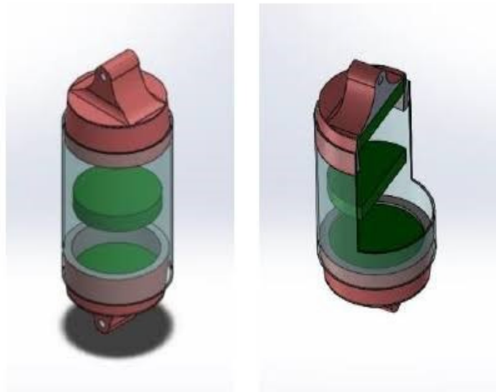

Fig. 1 Cross section

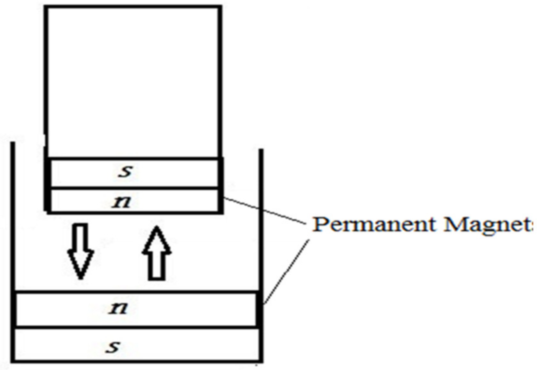

Fig.2Magnetic setup

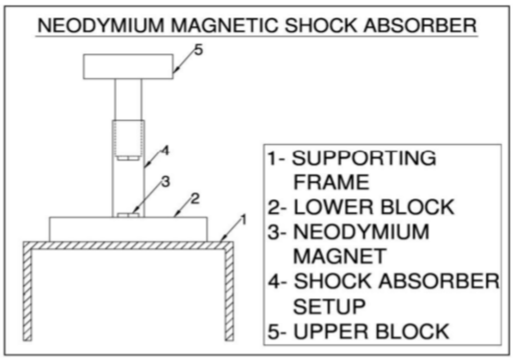

Fig. 3 Experimental setup

Fig. 4. Outer view

Fig. 5. neodymium magnet

Fig. 6. Load apparatus

Fig. 7. Magnetic property

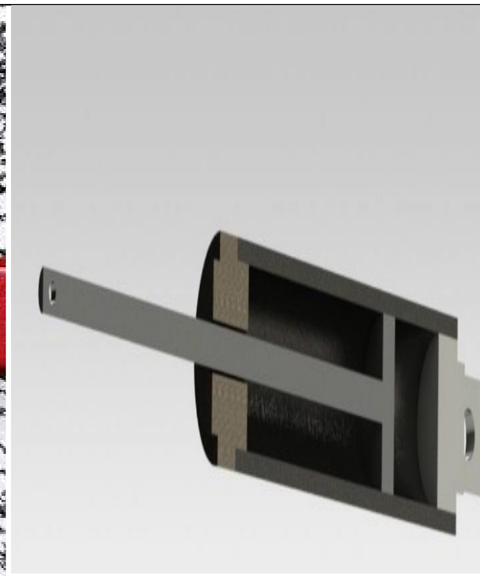

Fig. 8.Inner view

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