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DESIGN & MANUFACTURING OF MAGNETIC SUSPENSION SYSTEM

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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.*

Key Words: Magnetic Suspension, Permanent Magnet, Lubrication, Spring, Shock Absorber, etc.

1. INTRODUCTION

Magnetic Suspension is a shock absorbing device. Magnetic suspension is a method by which an object is suspended with no supports other than magnetic fields. Generally the suspensions are used as of spring type. The direct shock on spring is reduced in magnetic suspension. The magnets are arranged in a manner that gives more repulsion. Magnets are of required quality with required magnetic field strength. Magnetic suspension systems have been extensively studied and have found numerous applications. Most magnetic suspension systems are electromagnetic suspension systems (EMS systems) that utilize electromagnets, but here permanent magnets are used instead of that. Various mechanisms are used for various suspensions like wishbone, dual link, multi links, etc. When a lever (Bellcrank) used in suspension it consist of lever. The levitation directions horizontal, and in the equilibrium position, the magnet's attractive force is equal to the force of the suspended object. Then, based on the principle that the magnetic force is inversely proportional to the square of the gap between the magnet and the ferromagnetic body, the mechanism controls the air gap between the magnet as per load and the object so as to adjust the attractive force.

2. Literature review

"S. Gopinath, R.J. Golden Renjith, J.Dineshkumar"1): In this project two magnets are placed in a piston. One magnet is fixed with piston. Another one is movable, which is connected with rod. With magnets are replaced by air. Their magnetic shock absorber works on the basic principle of magnet that "opposite poles attract each other and same poles repel each other". In this both magnets are facing same poles (both magnets are placed facing north and north or south and south). When the rod moves inside the piston moveable 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. 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. At the same time, the stainless steel spring provided is freely inside the shock absorber. The additional support for magnetic shock absorber is provided by a helical coil spring, which was compressed at this stage. So the shocks and vibrations are prevented.

Chandrakant Chavan, G.M. Kakandikar, Swapnil S. Kulkarni 2): This paper is also based on the principle that like poles of magnet repel each other. This paper gives outlines magnetic suspension where two or more magnets of the same polarity absorb all the bumps. The design and analysis for rear wheel bike magnetic suspension is discussed. This paper describes techniques for the design, construction, and testing of a prototype magnetic suspension system. There is one magnet fixed at the top of the inner portion of the cylinder. The second magnet placed at bottom of the inner portion of cylinder that reciprocates up and down due to repulsion. The two magnets fight against each other to achieve the aspect of suspension.

Milica B. Naumovic & Boban R. Veseli 3): Described that the two magnets are placed in a piston. 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 repel 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 moves 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.

V.V.Borole and prof. K. K. Chaudhari 4): studied and described the Electromagnetic suspension system for automobile and studied different ways to recover energy from suspension system by using piezoelectric material to increase the efficiency of the automobile. Vehicle during running condition vibrate by means suspension operate by using motion of the shock absorber produce energy. Due to this tried to generate electricity from this system they proposed to use this electricity for headlamps and indicators etc. They also proposed to use these electro-magnets for preventing the tyres of vehicles from puncturing due to nails by attracting them to the magnets. Prof N. Vivekanand etc. all described about the analysis of suspension spring to determine and its fatigue life using finite element methodology. One of the most important part of the suspension system is the coiled spring which are helical in shape steel bar that absorb the shock. They also stated the advantages and disadvantages of conventional suspension systems, which helped us in designing a magnetic shock absorber in order to overcome the disadvantages of conventional suspension systems. They also stated design considerations of spring and due to this it helped in designing the spring in between the magnets.

B. V. Jayawant 5) described about the design and fabrication of magnetic suspension system. According to authors of these papers the coil spring suspension system have imitation that after some period of time coils become not only harder but also reducing cushioning effect and these limitation overcome by the new concept of ―magnetic suspension system‖ the cushioning effect provided by these system existing long life. They select material by considering Mechanical properties. This selection of materials also helped in selecting materials for the shafts, cylinder and sprin

Ayman A. Aly, and Farhan A. Salem 6) studied and described the disadvantages of other types of suspension system with magnetic suspension the material properties used for the magnet, coil spring, shaft according to author the magnetic system have more and more advantages than the air, hydraulic suspension. The hydraulic and air suspension have leakage problem and which is dangerous for any suspension system because of that big reason magnetic suspension system were used. Also, they discussed the all suspension system by comparing them with respect to their cost, material, maintenance, service life of the system etc. causing us to select proper suspension system in order to avoid maintenance and to improve the life of the system.

Feng Sun advisor Koichi OKA 7) focused on the magnetic suspension systems and the control systems using permanent magnets. First, an overview of the research background was introduced in a classification way, and the structure of this thesis was shown in chapter 1. Second, the research contents about the magnetic suspension systems using permanent magnets were exposited in three parts. Part I proposed a zero power control method using a spring and an integral feedback loop, and examined the zero power control method on two kinds of magnetic suspension systems with permanent magnets and linear actuators. They examined the zero power control method on a hanging type magnetic suspension system which can be applied as a noncontact conveyance vehicle. In chapter 2, the hanging type suspension principle was explained, and an experimental prototype was set up. A mathematical model was created. The suspension feasibility of the system was examined theoretically. The realization of zero power control was analysed in device, mathematical model, and control system. The numerical simulations and experiments were carried out in five cases. All the simulation and experimental results indicated that this hanging type magnetic suspension system could be suspended stably.

Rajasekar S, Dhamotharan J , Ejesh K. 8) : A shock absorber is a mechanical device designed to smooth out or (A slight wetness) damp a sudden shock impulse and dissipate kinetic energy. In a vehicle, it reduces the effect of traveling over rough ground. Without shock absorbers, the vehicle would have a bouncing ride, as energy is stored in the spring and then released to the vehicle, possibly exceeding the allowed range of suspension movement.

Aniket Bharambe 9): So in this paper we have introduced the idea of "MAGNETIC SUSPENSION" which will enhance the driving pleasure and control over road. Magnetic suspension will allow us to get variable stiffness and much higher comfort just by playing with magnetic field. It will also allow us to reduce wear and tear along with less maintenance. Finding the vehicle's handling and braking, and providing safety and comfort by keeping the vehicle's passengers comfortably isolated from road noise, bumps and vibrations. Magnetic suspension will be a best substitute for current problems and providing ultimate vehicle dynamics.

Hazril M. Isa; Wan Nor Liza Mahadi; Rahizar Ramli; Mohd. Azman Zainul Abidin 10) This paper discussing all the design literature review for electromagnetic suspension

systems for passenger vehicle. Electromagnetic suspension is the alternative for existing conventional suspension system that uses passive suspension system. Generally, linear motor is used in the design of the suspension. This is due to the behavior of the motor that can exert linear force directly to the attached load. In addition, the linear force from linear motor is controllable. This paper review with the effects of all types of electromagnetic suspension systems to the passenger's comfort. The reliability of fully active suspension system for vehicle also highlighted in this paper. A quarter-car model is used to assess the vehicle body vibration. This paper also deals with regenerative properties of linear motor that can improve the performance of lightweight vehicle.

Amar Prakash Nadipena Bhanu Kumar 11) 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.

Shekhar Yadav 12) : Magnetic Shock Absorber which is mainly based on the principle of magnetic property like when the same poles of two magnets come in contact with each other then they are repulsed from each other. This unit is mounted in vehicle such as other type of shock absorber. The working of this absorber is very simple. Two magnets are mounted in this way that one is mounted below and other is on upper side. Poles of these magnets are same at inner side so that they are repulsed from each other and space is made between them due to this. When the vehicle is running on the bump or the muddy road then the space between two magnets is reduced and then shocks and variations present in the vehicle are absorbed by repulsion property of the magnet. By using this type of absorber we can absorb the more number of shocks and variations with the more accuracy. This shock absorber has no problem of leakage of oil like hydraulic shock absorber. Also this has less maintenance than other types of shock absorbers. We can make this type of shock absorber for the efficient work of vehicle and for reducing the maintenance cost of vehicle.

Ronak Jain, Sagar Rao, K. Adithya Vignesh, Ranit Ash 13) In this paper, we look at the feasibility and design of electromagnetic suspension systems, and propose a hybrid design for the same. Firstly, we note and compare general design features of alternative systems. Then we review multiple design systems proposed and fabricated in earlier research, covering control strategies, programming, and mechanical linkage synthesis. Finally, we combine this information to generate a design that uses both new and traditional subsystems, aimed at balancing cost and quality of the product.

Munjal Mehta, Abhishek Panchal, Kishan Jha, Rutvik Prajapati 14) This suspension system has two parts the magnet part including a Permanent magnet and the frame part including the bell crank lever and another two links which makes mechanism connect with the magnetic arrangement with pvc pipe and reducers. This all arrangement is being mounted. In a working model of this suspension PVC pipe carrying 10 magnets floating arround it.

.Out of 10 magnets 3 magnets fixed in one reducer and a single magnet same in second reducer .other magnets floating on pipe in mode of repulsion .magnets are arrange in such manner that (4,3,2,1). In the frame there are several parts which is square bar.frame is a basic structure to hold the objects like wheel hub, suspension unit, links and more. The frame is joined by welding. The frame is made by M.S material and it support wheel hub very well because the weight of wheel hub is more.

Prof. Sagar S. Khatavkar, Mr. Dinesh Anchan, Mr. Prathamesh Deo, Mr. Samruddha Kale, Mr. Krushna Umate 15) This paper is a review on design and modification of electromagnetic suspension , rear suspension, magnetic suspension, uses of shock absorber etc. These are important aspects consider in below review done by various writers on a no. Of suspension systems developed by them. The function of suspension in any vehicle is to prevent shock during rough road condition and to enhance traction force between road surfaces. Any notable invention when taken into account it can be perceived that it has evolved greatly to reach such height by addressing their limitations.

AMA Soliman, MMS Kaldas MMS Kaldas 16) It is well documented that active suspension systems offer substantial benefits in ride comfort, handling control over traditional passive systems. However, restrictive features such as the power required and costs make an active

system impractical. To solve those problems, semi-active suspension systems have been developed. This paper aims at providing a review of the present state-of-theart in the semi-active suspension control field in terms of vehicle ride comfort and roadholding performance evaluation. Strengths and weaknesses of the semi-active suspension systems are identified and their relative performance capabilities and equipment requirements are discussed. Furthermore, examples of the current mass market implementation for semi-active suspension systems for road vehicle are discussed.

B Nandish* , K P Muthanna, M B Kaveriappa and P S Biddappa 17) This paper presents a research work on magnetic suspension system of two wheelers Automobiles, which are usually depending on spring type, Hydraulic and Pneumatic suspension systems. In this proposed magnetic suspension system, two permanent magnets made of Neodymium material are placed inside the shock absorber cylinder such that both facing same pole. So they produce a repulsive magnetic flux force, when they come closer due to shocking load. This repulsive magnetic flux force is used as shock absorbing media and provides damping force. Proposed suspension system proves to be more efficient over other type of suspension systems, absorb more number of shocks with high accuracy, has no leakage problem unlike in Hydraulic and Pneumatic system. So, all these beneficial qualities make the magnetic suspension system to work efficiently with less maintenance cost and hence the Automobile.

Daspute Sharad G. , Deshmane Shubham M., Dhage Prashant P. , Gaikwad Vaibhav J. 18) 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.

R.N.Yerrawara dr R.R.Arakerimathb 19) To implement semi active suspension system MR (Magneto Rheological) Damper is used .The current controller is developed to vary current from 0.1A to 1A. Design of Experiment (DOE) is a systematic method to determine the relationship between factors affecting a process and output of that process. In this paper Taguchi Method of DOE is implemented for optimization of ride comfort. Using MINITAB software L8 orthogonal array formulated with the total number of 8 runs. The semi active suspension parameters selected for performance are Sprung mass, spring stiffness and current with two levels of each parameter. A Quarter Car test rig equipped with NI 9234 data acquisition system is incorporated with provision of levels of each parameter. These are performed and the effect of these parameters on ride comfort is investigated. Experimental results are used to determine corresponding values in terms of signal-to-noise (S/N) ratio for each run. S/N ratio with lower is better characteristics is selected. ANOVA is performed and mean of SN ratio for each parameter is plotted to investigate which suspension parameter contributes highly in the performance of Semi Active suspension system.

Palash Agrawal, Amey Desai, Jaya Surya Malli reddy, Kiran Pralhad Wani 20) This research paper includes the design and development of semi active suspension system using the permanent magnet, electromagnet and its control. The combination of permanent magnets is used to withstand static load of 20 kg. The controller is used to deploy the control logic and decide the supply of the required quantity of current to the electromagnets. There are two inputs given to the controller, one of them is air gap between upper magnets and lower magnets and second is the nature of the road profile in terms of amplitude of irregularity of the road. Based on the values of these two inputs the current supplied to the electromagnet is varied which results in variable damping force. The experimental setup for semi active suspension is developed. It includes a metallic roller fitted with irregularity similar to road profile, chain and sprocket connected to electric motor, whose magnitude is sensed and given as an input to the controller. Based on this input value, the current supplied is varied as per the predefined look-up table in the control module. The experiments are conducted at different speeds resulting in frequencies of up to 2.5 Hz and road uneven surface of amplitude at least 10 mm. The response of the damper is observed using the linear potentiometer detecting the difference in motion of lower and upper magnets of the setup. The experimental results show that a semi active suspension system with proper selection and combination of number of permanent magnets and electromagnets can be designed for damping the vibrations for lower frequency up to 2.5Hz and static load applications of up to 20 kg.

3. Conclusion

Magnetic suspension can adapt to uneven road surfaces several hundred times per second, in fact it takes only a few milliseconds to adjust any one of the shock absorbers. The magnetic suspension system has the ability to give much smoother ride than any luxury sedan, and less roll and pitch than any sports car. The magnetic suspension gives more flexibility compared to the current or conventional types of suspension. Magnetic suspension allows us to change the stiffness also according to the requirement of the driver. Since there are less mechanical parts hence the amount of wear and tear in magnetic suspension is less. The magnetic suspension will provide a high end comfort since there is no limitation of spring compressing capacity or air/fluid compressibility. The magnets will repel as they possess same polarity and this will result in nullifying the vibrations which will ease the driving by increasing comfort level.

As we have seen the magnetic suspension is a revolutionary idea which will provide a comfortable ride by minimizing the vibrations and other factors. It would also allow setting the suspension stiffness as per requirement. Thereby magnetic suspension will be a best substitute for current problems and providing ultimate vehicle dynamics. An approach of the magnetic suspension system has been presented. The simplified mathematical model has been developed. The MSS has the ability to give much smoother ride than any luxury sedan, and less roll and pitch than any sports car.

REFERENCES

[1].. Gopinath, R.J. Golden Renjith, J.Dineshkumar "Design and fabrication of magnetic shock absorber" Vol 3, No 2 (2014).
[2]. Chavan, G.M.Kakandikar, Swapnil S. Kulkarni Review on "Design & Fabrication of Magnetic Suspension" Vol. 7, Issue, 10 October (2018).
[3]. B. Naumovic, BobanR.Veselic, Automatic Control and Robotics, —Magnetic Levitations Systems in Control Engineering Education||, 2008 pp.151-160.
[4]. V. V. Borole, prof. K.K.Chaudhari.—A Review On Magnetic Shock Absorber|| Mar-Apr 2015, pp 104-109.
[5]. V Jayawant, Rep. Prog. Phys.—Electro-magnetic Suspension and Levitation||, 1981
Vol. 416, No. 1851 (Apr. 8, 1988)
[6]. A. Aly, and Farhan A. Salem, IJCAS, —Vehicle Suspension System Control: A Review|| July 2013.
[7]. Feng Sun advisor Koichi OKA (Special Course for International Students) Department of Intelligent MechanicalEngineering, Graduate School of Engineering ,Kochi University of Technology, Kochi, Japan —Magnetic Suspension Systems Using Permanent Magnet|| August 2010.
[8.] Rajasekar S, Dhamotharan J , Ejesh K. : "Design and Fabrication of Magneto Rheological Damper"(VOLUME 7 – ISSUE 06).
[9]. Aniket Bharambe "Magnetic Suspension for Motorcycles", International Journal of Science and Research(IJSR),
https://www.ijsr.net/search_index_results_paperid.php?id=ART20161829, Volume 5 Issue 9, September 2016, 1092 – 1097.
[10]. Hazril M. Isa; Wan Nor Liza Mahadi; Rahizar Ramli; Mohd.AzmanZainul " International Review of Mechanical Engineering (I.RE.M.E.), Vol. xx, Manuscript received January 2007, "IMPLEMENTATION OF LQR CONTROLLER ON ELECTROMAGNETIC SUSPENSION SYSTEM FOR PASSENGER'S CAR"
[11]. Amar Prakash Nadipena Bhanu Kumar
"Design and analysis of magnetic suspension system" Volume 6 Issue 4.
[12]. Shekhar Yadav "Review on Design & Fabrication of Magnetic Suspension"Vol. 7, Issue 10, October 2018.
[13] Ronak Jain, Sagar Rao, K. Adithya Vignesh, Ranit Ash "Feasibility Study and Design of Electromagnetic Suspension Systems".
[14]. Munjal Mehta, Abhishek Panchal, Kishan Jha, Rutvik Prajapati "SPRINGLESS TYPE MAGNETIC SUSPENSION".
[15].Prof. Sagar S. Khatavkar, Mr. Dinesh Anchan ,
Mr. PrathameshVol. 3 Issue 3, March 2016.
"Electromagnetic Suspension System".
[16]. AMA Soliman, MMS Kaldas MMS Kaldas
"Semi-active suspension systems from research to mass-market ".First Published October 22, 2019
[17].B Nandish* , K P Muthanna, M B Kaveriappa and P S Biddappa "Neodymium magnetic shock absorber for two wheelers Automobiles" B Nandish et al 2019 IOP Conf. Ser.: Mater. Sci. Eng. 594 012037.
[18]. Daspute Sharad G. , Deshmane Shubham M., Dhage Prashant P. , Gaikwad Vaibhav J. "MAGNETIC SUSPENSION SYSTEM" Vol-3 Issue-1 2017.
[19]. R.N. Yerrawar and Dr. R.R. Arakerimath "Experimental Evaluation of Transmissibility for Magneto-Rheological Semi Active Suspensions System"
[20]. Palash Agrawal, Amey Desai, Jaya Surya Mallireddy, Kiran Pralhad Wani "Design and Development of a Semi Active Electromagnetic Suspension System" October (2019).