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Power Generation using the Electromagnetic Principle in Vehicle Suspension

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A B S T R A C T

The power generator electromagnetic suspension system is a system that converts vehicle bump-generated linear motion & vibration, into electricity to be used in battery charging. General vehicle shock absorbers are used to absorb this energy without converting it to electricity. So here we put forth a way to use this free energy and store it for further needs such as vehicle lights, cooling, indicator lights, etc. To achieve this, we here use the principles of electromagnetism in order to generate electricity from this motion. Our shock absorber comprises a metal shaft, spring, magnet, coils, base with screws and joints. It uses a coil wound around in particular a turning arrangement over the inner beam of the part. We use cylindrical supports in order to minimize friction and ensure smooth generation. The head of the absorber consists of magnets attached to the outer core aligned with the inner core to ensure smooth motion while ensuring efficient generation. This arrangement is fitted with springs in a precise manner so as to achieve the desired motion and magnet coil overlapping which allows for the generation of electricity through the electromagnetism principle. Thus, our system puts forward a smart power generation system using an electromagnetic suspension system.

Keywords: Suspension, Electromagnetic induction principle, Neodymium magnets, Copper coil, etc.,

INTRODUCTION

Energy and power have become so essential to our nation that it is now almost as important as air and water. Today it is generated from the different number of sources. Likewise, power can be generated through vehicle suspension by using Electromagnetic principle.

Need of Non-Conventional energy:

Non-Conventional energy has a bright future. Serious environmental problems are caused by increasing use of fuels. Hence there is a primary need to use renewable energy sources. India is a rich country in natural resources as well as population .In order to provide the demand of increasing population, we have to protect our natural resources by make use of them cautiously. Energy resources are considered to be the most needed resources. As the conventional resources are subject to exhaustion nature and cannot be renew right away. India's energy consumption grows faster than the major economies. Hence more study and growth are needed in these fields. In these projects we produce the electricity in an adept manner with the persists passing of the train, the generation of electricity will take place and destroy the problem of darkness at small halts. The need of non-conventional energy resources is gaining momentum in the country as well as in the country. India is now one of the countries implementing miscellaneous programs on the application and advancement of non- conventional energy resources. Rightly identifying the importance of the hour for the conservation of energy resources the planning commission of India in its Integrated Energy Policy Report has recommended the requirement to prosper domestic supply alternative and spread-out energy sources. The extension of the report state that non-conventional sources may account for 5 to 6 percent of India's total energy mix by 2031-32.

Power generation utilizing electromagnetic principles within a vehicle's suspension system. The integration of electromagnetic generators in suspension systems presents a promising avenue for energy harvesting, capitalizing on the mechanical energy generated during vehicular motion. This report provides an introduction to the key principles, potential applications, and engineering considerations associated with this groundbreaking approach. The pursuit of sustainable and efficient energy solutions has led to the exploration of unconventional methods for power generation. This report introduces the concept of employing electromagnetic principles to harness energy from the motion of a vehicle's suspension system.

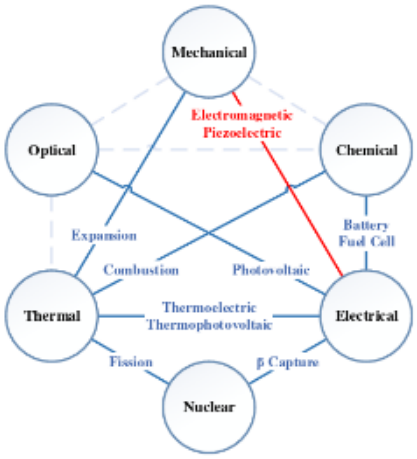

Fig. Energy types and the transformation mechanisms among them.

The power generator electromagnetic suspension system is a system that converts bump, force, linear motion & vibration into electricity. This electricity can be further used in glowing LEDs, low-watt bulbs, etc. Our system can be used in places where there are generations of vibrations, linear motion, or bumps such as treadmills, dance floors, staircases, etc. Our system uses capacitors to absorb this energy without converting it to electricity. So here we put forth a way to use this free energy and store it for further needs. To achieve this, we here use the principles of electromagnetism in order to generate electricity from this motion. Our system comprises a metal shaft, spring, magnet, coils, base with screws and joints. It uses a coil wound around in particular a turning arrangement over the inner beam of the part. We use cylindrical supports in order to minimize friction and ensure smooth generation. The head of the system consists of magnets attached to the outer core of the steel pipe which are aligned with the inner core to ensure smooth motion while ensuring efficient generation. This arrangement is fitted with springs in a precise manner so as to achieve the desired motion and magnet coil overlapping which allows for generation of electricity through electromagnetism principle. When force is applied to the system the permanent magnets perform the motion between coil winding. This results in the generation of magnetic flux due to which electric energy is obtained. This linear motion of the system uses a dense permanent magnet stack embedded on the small diameter steel pipe and coil winded on a pipe having a larger diameter. The springs are used for damping load. The electricity generated by each system can then be combined with electricity from other power generation systems and stored in the batteries. Since the coil produces alternating current, it can be directly used with respect to a certain condition.

MOTIVATION AND OBJECTIVE

Our main objective of the project is to produce electricity by using non-conventional energy Sources and utilize it for various purposes. Develop a power-generating suspension system by modifying the vehicle suspension through the electromagnetic principle. Utilization of generated power for various applications like LED light or a chargeable battery. To make vehicle suspension a power-generating device in vehicles generated power is stored in energy storage devices like chargeable batteries.

LITERATURE SUMMARY

Yilun Liu et al [1], proposed shock absorber consists of three modules: the ball screw, the enclosed MMR gearbox and the generator's clutches adopted in the proposed design have much smaller backlash. This low-backlash feature can increase the energy harvesting efficiency of the proposed shock absorber, especially when being used on smooth highways. The ball-screw shock absorber can still generate power under small excitation conditions. The results show that, when the modified vehicle is driven on a paved road at 40mph, the proposed energy-harvesting shock absorber harvest an average power of 13.3W for a representative period of 8 seconds**.**

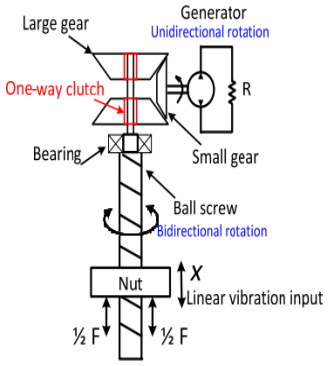

Fig. The dynamic model of the proposed energy-harvesting shock absorber

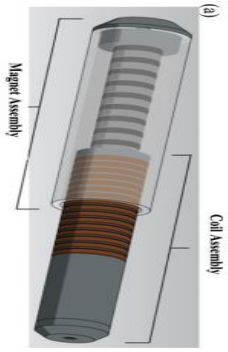

Fig. 3D model of the linear motor-based damper

Ran Zhang, Xu Wang et al [2], the current technologies of the regenerative shock absorber systems have been studied. Two types of power generating suspension systems i.e., Piezoelectric System and Electromagnetic System are taken for study and compared for best results. According to their research, more studies have been focused on the electromagnetic system as it is more feasible considering the modal resonant frequency of the vehicle, displacement of the shock absorber and its packaging size. In this Electromagnetic System, three drive modes of the regenerative shock absorber systems, namely the direct drive mode, the indirect drive mode and hybrid drive mode are reviewed for their design to be implemented. Their comparisons have been presented to understand the advantages and disadvantages in terms of conversion efficiency and compatibility.

Mechanism	Damping Coefficient	Maximum Damping Force
Direct drive system		
Electromagnetic system	N/A	520 N
Electromagnetic system	940 Ns/m	N/A
Electromagnetic system	1320 Nm/s	N/A
Electromagnetic system	1302–1540 Ns/m	N/A
Combination of MR damper and electromagnetic system	N/A	700 N
Combination of MR damper and electromagnetic system	N/A	520 N
Indirect drive system		
Rack and pinion	1425 Ns/m	N/A
Rack and pinion	38.5 Ns/m	N/A
Ball-screw	7200 Ns/m	N/A
Hydraulic system with 4 check valves for rectification	N/A	7343 N
Rack and pinion	N/A	700 N
Rack and pinion, two overrunning clutches	1637.2 Ns/m	N/A
Rod and helical slot	N/A	600 N
Hydraulic system	N/A	10,000 N
Algebraic screw	237 Ns/m	N/A
Ball screw with two one way clutches	15,420 Ns/m	N/A
DC generator connected to the hydraulic actuator	N/A	1450 N
Hybrid system		
Hydraulic piston with linear electromagnetic generator	1898 Ns/m	N/A

Table1: The summary of the damping performance of the regenerative shock absorbers.

Dattu B. Jagdale et al [3], proposed a system to generate power for electric vehicles by using the vehicle's suspension. The system converts the motion and vibrations caused by bumps on the road into electricity using special components like a metal shaft, spring, magnet, and coils. This free energy can

then be used for various purposes like lighting and cooling the vehicle. The researchers believe that it's important to explore alternative energy sources and see the potential of regenerative suspension systems in saving fuel. Their project focuses on designing and analyzing a suspension system that efficiently captures and stores this energy. The system offers benefits such as extending the range of electric vehicles, improving their stability and suspension, and increasing energy efficiency. It can be integrated into new and existing vehicles to help them travel longer distances without relying solely on batteries.

R. Shashank. et al [4], discussed about the design and development of suspension system for power generation. An automobile wastes over 74% f energy stored in the fuel as a heat. One of the most important losses occurred in the suspension system. Suspension system in the vehicles identifies the vibrations arising from the roads irregularities by the reciprocation of the coil springs. The power generation suspension system is designed and developed only for the coil spring type suspensions. An electromagnetic regenerative suspension system converts the kinetic energy caused by the springs to electrical energy and that can be easily stored and reused. The electricity generated was in the range of 125mV to 350mV, which is less but, it can be increased by using neodymium magnets which have high magnetic flux density. Also, by increasing the number of windings of copper coil will increase the potential difference generated. The energy generated were used for indicator lights, cooling system, display panel, etc.

S Logeshwaran et al.[5], focuses on to provide a comprehensive review on automobile regenerative suspension systems including various designs and mechanisms by discussing the need for energy harvesting in the automotive industry, as the traditional methods of power generation are becoming increasingly unsustainable .They go on to discuss the different ways in which energy can be harvested from suspension systems. The challenges that need to be addressed in order to make energy harvesting from suspension systems available option include improving the efficiency of the harvesters, reducing the cost of the harvesters, and developing ways to store the generated electricity.

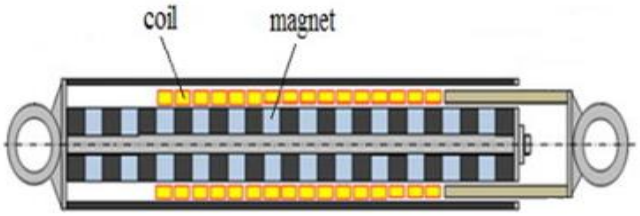

Fig. Linear shock absorber

Working principle of Electromagnetic Induction in Vehicle Suspension

The regenerative shock absorber converts suspension vibration between the wheel and the sprung mass into electrical power. The design consists mainly of a coil winding array and a permanent magnet array. The permanent magnet array is concentrically placed on a metallic rod which is of high magnetic reluctance. Along with the permanent magnets, the magnetic permeable spacers are stacked concentrically on the rod and they are placed in between permanent magnets. The permanent magnets are axis symmetrically magnetized and their orientation takes the form of N-S-S-N. This orientation allows the like poles to repel each other and the magnetic flux to move radially from the north to south of the permanent magnet. The coil windings array is basically a hollow cylindrical rod on which the coils are wound. An axial rod of magnetically permeable material is used to encase the permanent magnet array and also to reduce the reluctance of magnetic loops and thereby increase magnetic flux through the coils.

The electromagnetic induction principle states that there will be a development of voltage across the ends of a conductor in a magnetic field provided there exists relative motion between the conductor and the magnetic field. In this case, the relative motion is in between the coil windings array and the permanent magnet array. The voltage developed at the ends of a single conductor coil depends on the relative velocity V_Z, between the coil and the magnet array, the remanent magnetic field and the length of the conductor coil, l

$$V = BV_Zl$$

I give us the current produced due to the above emf set up in the coil depends on the electrical conductivity of the coil σ, the radial magnetic field of the permanent magnet B_r, the relative velocity $V_{z,}$ and the area of cross-section of the wire A_w.

$$I = \sigma\ B_rVz\ A_w$$

The magnetic field induced depends on the turn density, current, and the relative permeability of the conductor material. The length of the coil is given by

$$l = \pi D_cN$$

Where N the number of is turns of the coil and D_c is the average coil diameter.

DESIGN SPECIFICATIONS

Measurements from a conventional hydraulic shock absorber are taken. The outer cylinder OD is found out to be 30 mm and the ID is found to be 15 mm. The axial rod diameter is found to be 10 mm. The axial rod length is 190 mm. Make sure that all the necessary components of the assembly fit within

the outer cylinder of the design proposed and by employing the industrial standard N35 grade NdFeB permanent magnet of size 20mmx10 mmx10mm, static magnetic analysis was done. The OD and ID of the permanent magnets and magnetically permeable spacers are the same. The height of the spacers is taken to be 8mm. A copper coil of 30 AWG (American wire gauge) is considered with 300 - 400 turns for being the conductor. The coils are made to align with the permanent magnet array. The distance between respective coils is kept at 1mm. The coils are positioned such that they are 90° out of phase with each other. The coils adjacent to the permanent magnets at an equilibrium position will always give an output voltage of 0. Whereas the coils adjacent to the magnetic spacers will give positive and negative peak-to-peak values of the voltage generated. Fig.34. represents the model of the assembly incorporating all the above components based on the dimensions selected. The model was designed with the help of IRONCAD software for better visual understanding.

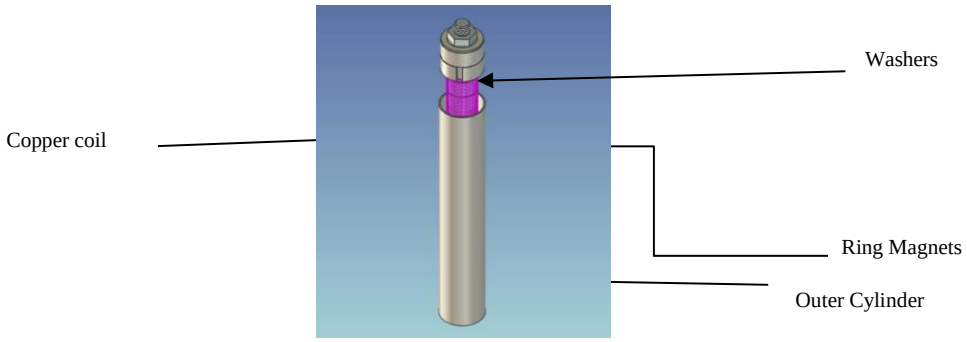

Fig. Assembly of suspension system with magnets and coil.

METHODOLOGY

Power generation using electromagnetic principle in vehicle suspension

Generating power using electromagnetic principles in a vehicle suspension system is an interesting experiment that can demonstrate the concept of energy harvesting. Here's a suitable methodology for conducting this experiment,

Materials and Equipment:

1. Small-scale vehicle suspension system (model or prototype)
2. Electromagnetic coil
3. Magnets
4. Multimeter
5. Wires and connectors
6. Load resistor (for testing)
7. Power source (battery or power supply)
8. Tools for mounting and assembly

Setup and Preparation:

Build or obtain a small-scale vehicle suspension system that can simulate the up-and-down motion of a real vehicle suspension. Mount the electromagnetic coil securely within the suspension system. Ensure that it can move relative to the suspension's motion. Connect the electromagnetic coil to the multimeter (set to measure voltage) using wires and connectors. Make sure the connections are secure. If you have an oscilloscope, connect it in parallel with the multimeter to visualize the generated voltage waveform. Attach Neodymium ring magnets of size (20*10*10) mm to the moving part of the suspension system, such as the shock absorber or a part that experiences vertical motion. Suspend the model suspension system and magnets in a way that allows it to move freely up and down. Gently move the suspension system up and down to induce motion in the coil. Observe the voltage output on the multimeter/Galvanometer. Note any changes in voltage as the suspension moves. Connect the load resistor to the output of the electromagnetic coil. Repeat the motion of the suspension system and observe how the coil's voltage output changes when a load is connected. Record voltage output over time as the suspension moves. Analyze the data to understand how the generated voltage varies with different suspension movements. Experiment with different coil designs, magnet placements, and suspension motions to optimize the power generation. Try varying the strength of the magnets or the

number of coil turns to see how it affects the output. Record your observations and findings in a notebook. Analyze the generated voltage and its relationship with suspension motion and other variables. Compare results with and without a load to understand the impact of power extraction.

EXPERIMENTATION

Disassemble the suspension system of the vehicle (Two-wheeler). Measure the dimensions of the hollow cylinder and the axial rod of the suspension system. Take a hollow cylinder (22 *20*170) mm and wind the copper coil (AWG 30) around the hollow cylinder nearly (300-400) turns. Take 3 pairs of Neodymium ring magnets (20*10*6) mm and insert them over the axial rod as repulsive poles of each pair. Take the two terminals of copper coil outside the hollow cylinder and connect them to the wires. A booster module is used for stepping up the voltage that is produced. Then a diode) is connected to the setup and extended to the capacitor as a circuit. Assemble the parts of the suspension system and fix the vehicle. Now, drive the vehicle on the uneven surface for the experience of suspension in the vehicle. Then, check the voltage which is generated during the suspension with the help of a Multimeter or Galvanometer. Repeat the procedure by taking a greater number of copper coil turns at different speeds.

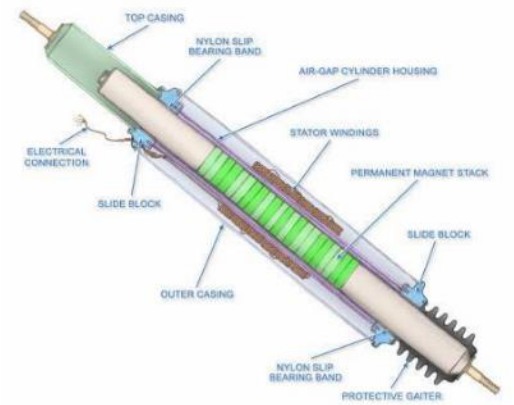

Fig.2. Linear Electromagnetic Suspension

RESULTS AND DISCUSSION

To measure the potential drop occurring in the current-carrying conductor, the ends of the copper coil windings were connected with wires. The other end of the wires was connected with multimeter adapter pins. Multi-meter was used to measure the potential drop occurring at the current-carrying conductor due to the spring actuation. The voltage reading obtained was in the range of 350 mV to 1000 mV. Upon increasing the actuation speed, the voltage was increased up to 1500 mV. The results of the electricity generated from the suspension system for power generation in terms of voltage are depicted in Table 3. The results show that the voltage reading is decreasing when the number of windings is reduced. The highest reading of the test is 1500 mV at 50 Hz for 2000 turns of windings, 850 mV for 1000 turns of windings and 400 mV for 400 turns of windings. It can be observed that 40 Hz frequency produces higher volt age output from the test. Resonance occurs at frequency of 50 Hz that generates highest voltage output. The lowest value of volt age generation is in the frequency of 10 Hz. This is because the velocity is slowest among others and the magnetic induction is lowest.

	Voltage(mV)		
Number of windings	**400**	**1000**	**2000**
Frequency			
10	10	70	450
20	70	100	700
30	120	350	1025
40	210	500	1250
50	400	850	1500

Table 2.Voltage reading different number of windings

Fig Potential Difference reading of Suspension System for Power Generation

CONCLUSION

The aim of this paper was to present a comprehensive review on automobile energy harvesting based suspension and its associated critical issues including designs, mechanisms, energy flow as well as the conducted simulations, bench tests, and real road investigations on wheeled vehicles. The corresponding energy-harvesting based damper configurations and types were debated in details. Thereafter, the present research challenges were discussed and future work was suggested regarding real applications in wheeled vehicles. Unlike small-scale energy-harvesting systems (e.g., wireless sensors and electronic devices), automobile energy harvesting based suspensions have not been sufficiently investigated. Vehicles while being driven result in enormous loss of energy through the suspension system which is a pity. The Suspension System prototype for power generation shimmers and propounds a way to regenerate the energy lost. While there are a lot of regenerative techniques, the Suspension system for power generation espouses simplicity in design, and adaptability to a large variance of vehicles and dwells on having as little expanse as possible. The electricity generated was 350 mV to 1000 mV (with increased actuation speed, up to 1500 mV), which is less. Still, it can be increased using a greater number of windings of copper wire will increase the potential difference generated.

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