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Energy Harvestingin the Vehicle Suspension System

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ABSTRACT

Energy harvesting using suspension systems is an emerging field that aims to convert the energy dissipated during vehicle motion into usable electrical energy. The suspension system of a vehicle experiences a significant amount of vibration and oscillation duringa normal operation, which can be harnessed and converted into electrical energy.

The energy harvested from the suspension system can be used to power various electrical systems of the vehicle, such as the headlights, air conditioning, or charging the battery. This approach can lead to improved fuel efficiency, reduced emissions, and increased reliability of the vehicle. Reducing the overall dependence on the vehicle's battery and alternator.

In this paper, we review the various technologies and techniques used for energy harvesting using suspension systems, including piezoelectric, electromagnetic, and electrostatic methods. Overall, an electromagnetic generator in a suspension system can provide a reliable and efficient way to harvest the kinetic energy of a moving vehicle and convert it into electrical energy. This approach has the potential to improve the fuel efficiency and reduce emissions of the vehicle, while also improving its overall performance and reliability. We also discuss the challenges and limitations of these techniques and highlight potential areas for future research and development.

KEYWORDS: Energy harvesting, The Suspension system, Electrical Energy generation, Electromagnetic, Kinetic Energy, Vibrations.

1.INTRODUCTION

Generating electricity using a suspension system is a concept known as "kinetic energy harvesting." Energy harvesting using suspension systems is a promising technology that enables the conversion of kinetic energy from the suspension system of a vehicle into electrical energy, which can be used to power various electronic devices. Suspension systems are an essential component of any vehicle, and they are responsible for providing a smooth and comfortable ride by absorbing shock and vibration. By harnessing the kinetic energy generated by the suspension system, we can not only improve the efficiency of the vehicle but also reduce its carbon footprint.

The principle of energy harvesting using suspension systems is based on the conversion of mechanical energy intoelectrical energy through the use of electromechanical devices. As a vehicle travels over rough terrain or bumps in the road, the suspension system moves up and down. By placing a kinetic energy harvester within the suspension system, the movement of the suspension can be converted into electrical energy. These devices can generate an electric current when subjected to mechanical stress or deformation, which is then stored in a battery or capacitor for later use.

There are several different types of kinetic energy harvesters that could be used in suspension systems, including electromagnetic generators, piezoelectric materials, and electrostatic generators. Each type of harvester has its own advantages and disadvantages in terms of efficiency, cost, and durability.

In recent years, significant advances have been made in the development of energy harvesting technologies, which has led to the integration of these systems in various applications, including electric and hybrid

vehicles, as well as other transportation such as trains and trams.

2. LITERATURE REVIEW

The primary motifs of interest will be covered in this literature review. The design of spur gears, DC generators, shafts, comportments, and shock absorbers is covered in the literature reviews along with theoretical and experimental evaluation.

"Design of Electromagnetic Shock Absorbers for Energy Harvesting from Automobile Dormancies," Pei Sheng Zhang, 2010. The various types of suspension systems were discussed in this paper. Moreover, the rack and pinion setup in the suspension car.

"Interspersing current and Direct current creator," Pedro Portela, Joo Seplveda, and Joo Sena Esteves, 2008. In this study, generators that generate direct current (DC) are referred to as guns, while generators that generate alternating current (AC) are referred to as alternators. The system presented in this work is a generator capable of providing an electrical load with the requested type of current, such as direct current or interspersed current.

"Design and static glamorous analysis of electromagnetic regenerative shock absorber," by Dr. S.S. Gawade and Rahul Uttamrao Patil Systems for electronic clothing are ideal systems. Moving vehicles have an impact on the environment around the road due to the weather. Shock absorbers are therefore important for protecting electrical equipment in moving cars. A thorough analysis of the design or evaluation of a shock absorber for the protection of electronic equipment systems in challenging vibration-impact terrain is presented in this study.

3. DESIGN PRINCIPLE

Since we want to match the excitation and resonant frequencies, spring stiffness is generally crucial to the design of a vibration energy harvester. Yet, road roughness—which is typically arbitrary and which is frequently modellable as white-noise hurried input to the tires—is the primary source of vehicle suspense. For profitable execution without altering the suspense structure or suspense stiffness, build design is also crucial. As a result, we would like to create regenerative shock absorbers that can easily replace the conventional oil painting mute in order to accomplish the desired damping while capturing energy. Regenerative shock absorbers can be made in either a direct design or a rotational design, which are the two most common forms. The direct- type shock absorbers use the relative stir between glamorous field and coils to directly induce power grounded on Faraday's law of electromagnet-induction.

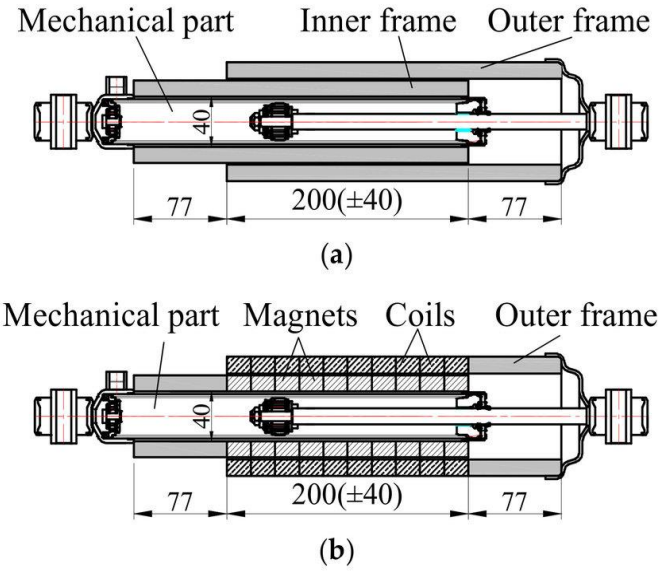


Fig.1 2D layout of Suspension System.

The direct-type of shock absorbers rely on Faraday's law of electromagnet-induction, tells which is based on the relative motion between the magnetic field and coils, to directly induce power. In order to power infinite gorgeous DC creators, the rotary shock absorbers transfer direct motion of suspension vibration to rotary stir. Rotating shock absorbers are typically capable of producing more power and obtaining a bigger damping measure for the available space. Several mechanisms, such as ball- screw and rack pinion mechanisms, could be utilised to convert direct stirring to rotary stirring. In spite of this, we opt for the rack-pinion medium due to the ball-screw harvester's poor performance in frequent use.The transmission can also be rotated by 90 degrees using a set of bevel gears.A planetary gearbox is used for stir exaggeration since the affair voltage is proportional to the rotating speed.

4. WORKING PRINCIPLE OF ELECTROMAGNATIC GENERATOR

Electromagnetic generators convert mechanical energy into electrical energy using the principle of electromagnetic induction. The basic working principle of an electromagnetic generator involves the following steps:

The generator consists of a coil of wire and a magnet, with the coil placed in a magnetic field created by the magnet.

By cutting through the magnetic field lines when the wire coil rotates within the magnetic field, Faraday's law of electromagnetic induction causes a voltage to be induced in the wire.

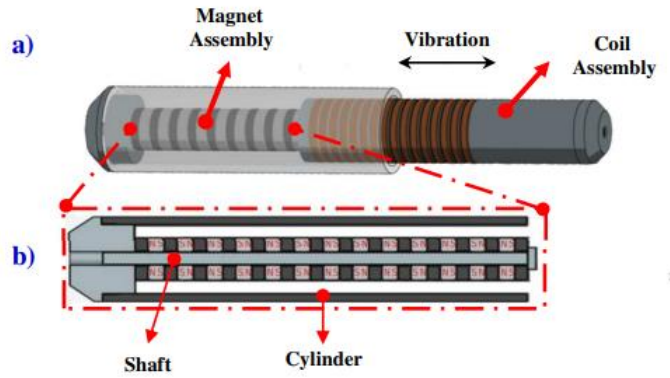


Fig. 2 The Suspension System with a prototype model.

The magnetic field's rate of change, which is influenced by the coil's spinning speed and the strength of the magnetic field and which determines the voltage produced in the wire coil, is proportional.

Since the voltage produced is an alternating current (AC), its direction and strength change over time. The generator's AC output is often rectified into direct current (DC) before being used to produce electricity.

The electrical output from the DC converter can then be used to power devices or saved in a battery for later use.

The specific design and construction of an electromagnetic generator can vary depending on the application and the requirements of the system. However, the basic working principle of electromagnetic induction remains the same. By rotating a coil of wire within a magnetic field, electrical energy can be generated from mechanical energy, making electromagnetic generators an important component of many different types of electrical systems.

5. WORKING

An electromagnetic generator in a suspension system typically consists of a coil of wire and a magnet. The coil is mounted to the body of the vehicle, while the magnet is attached to the suspension system. As the vehicle moves, the suspension system oscillates, causing the magnet to move relative to the coil.

According to Faraday's law of electromagnetic induction, an electric current is induced in the coil when a magnet moves past it, creating a magnetic field in the process. The vehicle's different electrical components can then be powered by the electric current generated in the coil, or it can be stored in a battery for later use.

Fig. 3The Suspension system with free body.

The capacity of the magnetic field, the number of turns in the coil, and the speed of the suspension system are some of the variables that affect how much electrical power the electromagnetic generator can produce. The coil and magnet should be properly built and positioned to maximise their interaction in order to increase the quantity of power generated.

Fig. 4The Suspension system while pressure is applied.

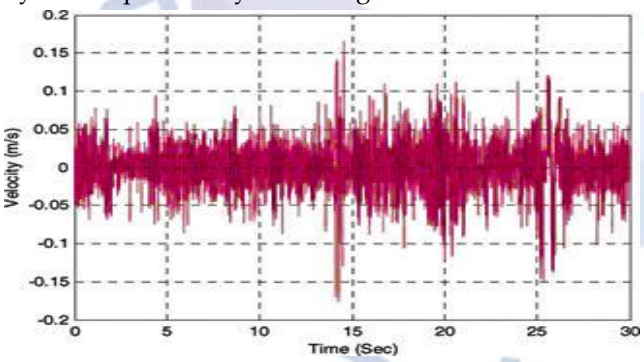
An electromagnetic generator can convert the kinetic energy of a moving vehicle into electrical energy reliably and efficiently in the suspension system. This approach has the potential to improve the fuel efficiency and reduce emissions of the vehicle, while also improving its overall performance and reliability.

6. RESULTS

Vehicle Suspension Energy Generation is extremely effective and helpful in converting Kinetic Energy from the movement of the vehicle, particularly the suspension, which typically goes to waste, to electric energy that can be utilized to meet the demands of the auxiliaries in the vehicle.

Nowadays, a specialised alternator that is connected to an IC engine shaft charges the batteries of cars. In order to rotate the alternator and charge the battery, gasoline utilised in vehicles must be used. This consumption, which accounts for 4% of overall consumption, is determined to be the case. The "alternator-based"regeneration system is disconnected from the engine and connects to the suspension system through newly developed suspension.

Through the development of the Suspension System model, we analyzed the readings of the power generated by the suspension system are given below.



Graph1: The Suspensionvelocitybetweenthesprungandunsprungmass esrecordedonaStreatRoadat30km/h(18.64mi/h)

We ride the vehicle at different speeds on local roads and find the velocity(m/s) and power generated(w) by the suspension system are given below

Table 1

Vehicle Speed	RMS suspension velocity (m/s)	Dissipated power estimation (W)*
32 km/h (20 mph), local road	0.026	13.5
48 km/h (30 mph), local road	0.052	54.1
64 km/h (40 mph), local road	0.084	141.1
88 km/h (55 mph), highway	0.077	118.6
96 km/h (60 mph), highway	0.090	162.0

*The power is estimated based on four shock absorbers, and dissipated power is calculated as $P = cv^2$, where c represents the damping coefficient and v represents the suspension's relative velocity.

Table. 1 Measured the suspension vibration,vehicle speed and calculated power

As compared to the other Energy Harvesting devices this model has high efficiency in producing more power and powering more auxiliary devices.

7.CONCLUSION

The creation of vehicle suspension energy is unquestionably beneficial and successful in converting kinetic energy from the movement of the vehicle, particularly the suspension, which typically goes to waste, into electric energy that can be utilised to power the auxiliaries in the vehicle. Nowadays, a specialised alternator coupled to the IC machine shaft charges the batteries of automobiles.The developers designed the four wheels to consume the same amount of energy as the alternator, which rotates to recharge the battery in motor vehicles. They disconnected the regeneration system, which now uses an alternator, from the engine and connected it to the suspension system through a newly developed suspension.Installing this regeneration device on all four wheels will increase the amount of electric power generated. This large amount of electricity may be utilised to operate the refrigeration or auto air conditioning systems in cars. For big pressurised trucks, milk exchanges, fire squad exchanges, as well as those with significant electrical demands inside of them, this suspension system will be quite helpful. We can see from the result table that the highest voltage and current are obtained for a limited number of gear teeth.

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