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Energy Harvesting System from Speed Breaker for Sustainable Power Generation

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Abstract

Exploration of alternate and sustainable power generating systems has become necessary due to the rapid increase in global energy consumption, the depletion of conventional fossil fuel resources, and growing environmental concerns. Creating an energy harvesting system from road infrastructure—specifically, speed breakers—to produce clean, renewable electricity is one creative strategy. This method makes use of the kinetic energy generated by moving vehicles over speed limiters, which would otherwise be squandered as vibrations and heat. Through the use of electromechanical devices like generators, piezoelectric transducers, or hybrid electromagnetic-piezoelectric systems, the vertical motion of vehicles is converted into rotational or compressive mechanical energy, which is then converted into electrical energy. The collected energy can be effectively stored in supercapacitors or batteries, which can then be used to power traffic signals, street lights, security systems, or even be connected to the local grid for communal use. Modern human life depends on energy, yet traditional energy sources are running out quickly.

Introduction

One of the most essential necessities of contemporary society is electricity. Homes, businesses, transportation networks, and communication systems are all powered by it. However, fossil fuels like coal, oil, and natural gas are used to generate the majority of today's power. In addition to being scarce, these resources contribute to major environmental issues including air pollution and global warming. As a result, scientists are looking for environmentally acceptable and renewable energy sources to satisfy the rising need for electricity.

Alternative energy sources are becoming more and more popular as a result of rising energy demand and concerns about environmental sustainability. Fossil fuels are frequently used in conventional power generation processes, which contribute to pollution and climate change. The energy that is captured can be used as a backup energy source for off-grid or remote applications, to help fulfill local power demands, and to support sustainable development. In this study, we outline the approach, design, and experimental findings for a power generation system based on speed breakers. The suggested system is examined in terms of power production, efficiency, and possible scalability, offering a thorough assessment of its suitability for use in practical situations.

Researchers are therefore looking at creative explanations that can improve the energy mix while reducing negative environmental effects. Using the energy from speed breakers, which are common in suburban and urban areas, is one such method. The growing demand for energy worldwide and the constraints of traditional energy sources are the driving forces for the development of a speed breaker energy harvesting device. With more people living in cities throughout the world and more cars on the road, there is a huge opportunity to capture the kinetic energy of moving cars that would otherwise be lost. The system can offer an environmentally friendly way to meet urban energy needs, particularly in places with heavy traffic.
[1].

Making electricity from the motion of cars on the road is an intriguing concept. A significant quantity of kinetic energy is lost as heat and vibrations when cars go past speed limiters. This energy has the potential to be a sustainable energy source if it is captured and transformed into electrical power that is useful. We refer to this idea as speed breaker energy harvesting. Modern society depends heavily on electrical energy, which is the basis for many technological and economic developments.

Conventional energy sources like fossil fuels are getting more and more depleted and unsustainable in terms of the environment as the demand for electricity keeps rising. Alternative energy sources are becoming more and more popular as a result of rising energy demand and concerns about environmental sustainability. Fossil fuels are frequently used in conventional power generation processes, which contribute to pollution and climate change. Because of this, scientists are looking toward creative explanations that can improve the energy mix while reducing harmful effects on the environment. Using the energy from speed breakers, which are common in suburban and urban areas, is one such method [2].

There are various benefits to this approach. It is economical, uses energy that would otherwise be wasted, and doesn't cause pollution. The amount of energy that may be captured is substantial because cities and highways already have a high volume of automobiles. It is particularly helpful in places with lots of people and traffic. Investigating alternate and sustainable energy sources has become necessary due to the sharp rise in the world's energy use and the depletion of traditional fossil fuels have made it necessary to investigate sustainable and alternate energy sources. Using the enormous potential of mechanical energy produced by vehicle movement, energy harvesting from road infrastructures has become one of the most promising areas of renewable energy solutions [3].

For this goal, researchers from all around the world have studied a variety of ways, including hybrid models that integrate several approaches, electromagnetic systems, and piezoelectric materials. Research has demonstrated that these systems are robust enough for practical application and are capable of producing substantial amounts of electricity. Supercapacitors and other advanced materials and storage technologies can further increase dependability and efficiency [4]. Society may lessen its reliance on fossil fuels, cut greenhouse gas emissions, and transition to cleaner and greener energy production by implementing such technology. Speed breaker energy collecting, which makes cities smarter and more energy efficient, is thus a promising step toward sustainable development. Researchers and engineers are investigating novel approaches to power generation in response to the growing demand for sustainable energy solutions. Energy needs are constantly rising due to the quick urbanization and growth of smart cities, and conventional fossil fuel-based sources provide both financial and environmental difficulties. The growing demand for renewable and sustainable energy around the world has prompted academics to look into unusual power generation methods Modern society depends heavily on electrical energy, which is the basis for many technological and economic developments [5]. Searching for sustainable and alternative power generation methods has become essential on a worldwide scale due to the growing demand for electricity and the depletion of conventional energy resources. Energy harvesting from mechanical vibrations and movements is one of the many renewable energy sources that has drawn interest because of its potential in urban settings. Particularly on roads, there is a lot of mechanical stress and vibration produced, which is frequently squandered. As the demand for electricity continues to grow, conventional energy sources such as fossil fuels are becoming increasingly depleted and environmentally unsustainable [6].

Literature Survey

This Paper Study on Power Generation from Speed Breakers (2025). This study explores

both conventional and non-traditional energy sources for power generation.
It demonstrates how kinetic energy from vehicles can be converted into rotational and then electrical energy using a specially designed speed breaker mechanism. The research highlights that, despite several methods like hydraulic, rack and pinion, and piezoelectric systems, standardized design and optimization suitable for real- world road conditions are still lacking [1].
This Paper Study Electrical Power Generation Using Speed Breaker Mechanism: An Innovative Approach to Energy Harvesting (2024). This work introduces a system that utilizes a rack and pinion setup integrated into a speed breaker to convert the kinetic energy of moving vehicles into electricity. The approach emphasizes mechanical-to- electrical energy conversion for sustainable power generation. However, it identifies a major research gap in efficiently capturing the mechanical energy wasted on roads and optimizing its use for practical applications [2]. This Paper Study the Developments in Energy Harvesting from Road Infrastructures (2023). The study focuses on various road-based energy-harvesting technologies such as electromagnetic systems, piezoelectric devices, solar panels, and thermoelectric generators. These technologies aim to utilize the energy potential of road infrastructures, including speed breakers. Still, challenges persist in creating efficient and durable systems for continuous and large-scale energy harvesting [3].
This Paper Study The Energy Harvesting Through Speed Breaker Using Piezoelectric Materials (2022). This research proposes a hybrid energy harvesting system that combines piezoelectric and electromagnetic methods to improve output and reliability. The hybrid design enhances efficiency compared to pure piezoelectric systems, making it suitable for smart city power solutions. However, it also introduces challenges such as higher costs, complexity, and a lack of practical implementation at large scales [4]. This Paper Study the Hybrid Energy Harvesting from Vehicular Movements for Smart Cities (2021). This concept integrates mechanical, piezoelectric, and electromagnetic systems to harvest energy from vehicle motion, providing localized power for urban infrastructures. While it offers potential for sustainable smart cities, limitations such as low efficiency, high installation costs, and limited real-world testing restrict its broader adoption [5].
This Paper Study The Piezoelectric Based Energy Harvesting System from Speed Breakers (2020). The system captures kinetic energy from vehicles passing over speed breakers and converts it into electrical energy through piezoelectric materials. The generated energy is conditioned, stored, and used for local applications. Despite its promise for sustainable energy production, challenges like low output, material durability, and lack of large-scale testing hinder its practical implementation [6].

Methodology of Review

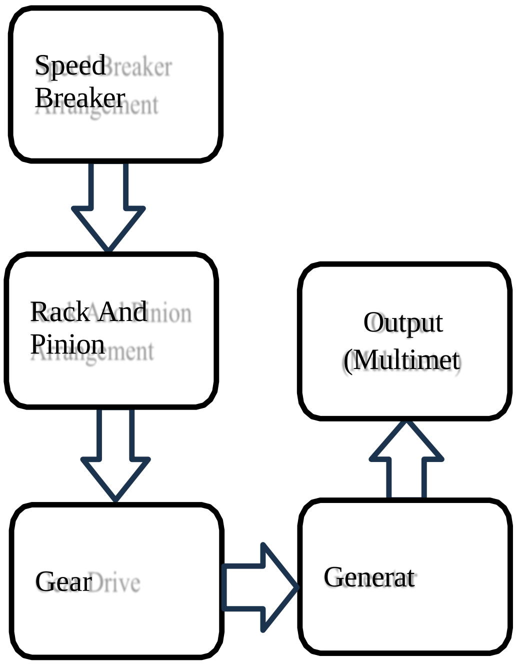

Fig 1: Functional Block Diagram

One of the most common sources of energy that we use is electricity, which is a fundamental component of nature. Every time a car goes over a speed breaker, a significant quantity of energy is lost due to friction and heat loss.
In this study, a roller is positioned between a speed breaker and the breaker itself has a grip of some sort, which causes the vehicle to shift vertically downward as it passes over the breaker.
Simultaneously, the rack that is attached to the speed breaker descends the same distance. The pinion that is connected to the generator motor is meshing with the rack, which is meshing with the pinion that is connected to the gear shaft.
This entire system transforms linear displacement into rotational motion. As a result, the generator's shaft revolves, producing a current that is proportionate to the pinion's revolutions.
The battery stores this generated current for

later use. Later, the spring mechanism causes the rack to shift back to its initial position.

This project's study methodology uses a specially made speed breaker to transform automobiles wasted kinetic energy into electrical energy that can be used.

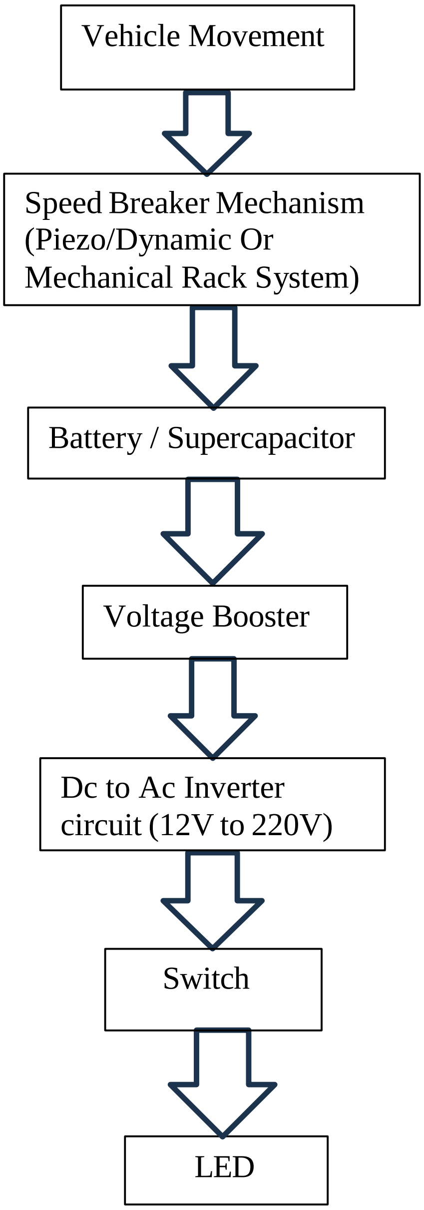

Fig 2: Flow Diagram of System

Discussion

With a power output closely correlated with the vehicle's weight and the frequency of cars crossing the speed breaker, the suggested speed breaker energy collecting device demonstrated encouraging results. The greatest output of a vehicle carrying a 20 kg load was 3.63 watts, and the amount of energy gathered each minute changed according to the volume of traffic.

As a result, the suggested system's overall efficiency increased from 77% in previous designs to 82.9%. The suggested system performed competitively when these results were compared to those of related investigations. For example, a speed breaker-based energy harvester using a different mechanical-to-electrical conversion mechanism achieved an efficiency of roughly 2.7 watts, according to a study by Pirisi et al. (2013).

Similar to this, Zhang et al. (2016) created an electromagnetic energy harvesting system for use in roads and, under similar load conditions, managed to produce a power output of 3.2 watts with a system efficiency of 78%.

The system, which detects the vertical displacement brought on by moving vehicles, usually consists of a mechanical assembly coupled to a generator, piezoelectric components, or a hydraulic arrangement.

The electricity produced can then be utilized directly to operate small-scale public utilities, traffic signals, lighting, and toll booths, or it can be stored in batteries. In areas with limited power availability, this localized energy solution promotes the development of infrastructure in rural or semi- urban areas while lowering reliance on traditional power networks.

Calculation

Let, Normal car mass = 1500kg (Avg.)

Car weight = acceleration due to gravity*Mass =1500kg * 9.81 m/s^2=14715N

Speed breaker height = 15cm=0.15m

Work done =Displacement*Force= 14715*0.15=2207.25Nm Power = Work done/ time = 2207.25 /60 = 36.7875W

Power generated in the whole day = 36.7875*24hr*60min

= 56.45KW

If we are using a bulb which is 100W, and in two km 120 numbers bulb needed.

The total watt consumed =120*100 =12000W = 12KW

Future Scope

1) Create, build, and test an effective power generation system that incorporates speed breakers.
2) Research various mechanical mechanisms, such as rack and pinion or spring-loaded systems;
3) Assess energy output according to vehicle weight and traffic density.
4) Integrate the system with storage units and local streetlight networks.
5) Test real-time performance in a variety of weather and road conditions.
6) Evaluate the system's payback period and cost-benefit analysis for urban implementation.
7) Investigate options for highway grid

integration and scaling.
8) Create awareness campaigns for public and stakeholder communication.

Conclusion & Challenges

- Speed-breaker energy harvesting is a practical approach for localized, small-scale power generation (e.g., street lighting, sensors, signage), but not a substitute for large-scale generation.
- Multiple transduction approaches (mechanical rack- and-pinion + generator, electromagnetic, piezoelectric, and hybrids) can be used; hybrid systems generally raise yield and reliability.
- The principal benefits are utilization of otherwise wasted kinetic energy, potential for distributed renewable supply in smart-city applications, and reduced reliance on mains for low-power loads.
- Economic and operational feasibility depends strongly on traffic volume, device efficiency, installation/maintenance costs, and durability; targeted deployment in high-traffic, low- maintenance locations offers the best return.
- To move toward practical deployment, coordinated pilot trials, standardization, life-cycle assessments, and integration with storage and energy-management systems are needed.

Challenges

- Low and intermittent energy output: Per-vehicle energy is small and highly dependent on traffic density and vehicle speed.
- Mechanical durability and fatigue: Repeated heavy loads cause wear, fracture risk, and require robust sealing against water, dust, and corrosion.
- Cost-effectiveness and payback: High upfront and maintenance costs can outweigh energy value unless systems are optimized or subsidized.
- Road integration and safety: Structural modifications, uneven surfaces, or unexpected vehicle responses can create safety and compliance concerns.
- Maintenance, accessibility, and operational disruption: Repairs require road access, potentially causing traffic interruptions and additional logistic costs.
- Power conditioning and storage losses: Converting short, high-power pulses into usable steady power requires efficient electronics and storage, which add cost and losses.
- Regulatory and institutional barriers: Lack of standards, permits, and road-authority acceptance can delay adoption.
- Environmental and lifecycle issues: Material recyclability, end-of-life disposal, and any added vibration/noise impacts on vehicles and surroundings must be managed.

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