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Piezo Electric Smart Road

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Abstract: *The integration of piezoelectric materials in the development of smart roads represents a promising innovation to enhance the efficiency and sustainability of modern infrastructure. This concept involves embedding piezoelectric sensors and generators within road surfaces to capture mechanical energy from vehicle traffic, which can then be converted into electrical energy. This energy can be used to power roadside systems such as traffic lights, street lamps, and road sensors, as well as contribute to the broader electrical grid. Additionally, piezoelectric sensors embedded in the road can monitor vehicle speed, weight, and traffic flow in real-time, providing valuable data for traffic management systems and enabling more responsive, data-driven infrastructure management. The key benefits of piezoelectric smart roads include reduced reliance on traditional energy sources, real- time monitoring capabilities, and the potential to create self-sustaining transportation systems.*

Keywords: Piezoelectric Effect, Smart Roads, Energy Harvesting, Sustainable Energy, Infrastructure

I. INTRODUCTION

Traffic on roads worldwide is increasing daily, thus congestion on roads is becoming inevitable with the rise in personal transportation. The correlation between energy demand and heavy traffic motivates the concept of roads that can harvest energy from moving vehicles. For this, piezoelectric material embedded beneath a road, the Piezo-smart road, can provide the magic of converting pressure exerted by the moving vehicles into electric current.

The increasing demand for sustainable and clean energy has driven the search for alternative energy sources to address environmental pollution (e.g., nuclear power waste and gasoline emissions) and the limited availability of non-renewable resources.

II. PIEZOELECTRIC EFFECT

The piezoelectric effect is a phenomenon in which certain materials generate an electric charge when subjected to mechanical stress and deform when exposed to an electric field. Discovered in 1880 by Pierre and Jacques Curie, this effect involves the generation of a voltage when mechanical force is applied to certain crystalline minerals.

When a force is applied on a piezoelectric material, this results in the development of a charge in this material.

III. LITERATURE REVIEW

Previous studies have explored the generation of electricity from roads using piezoelectric sensors.

- Pravin Wale et al. (2021) demonstrated the feasibility of generating electricity from roads using piezoelectric sensors.
- Priyanka Baniya et al. (2019) focused on implementing reliable and environmentally friendly renewable energy sources using footstep power generation.
- Abdul Fataha et al. (2018) highlighted the potential of Piezo Smart Roads to supply electricity to traffic signals, charging stations, and streetlights.
- Jaskaran Kaur and Abhinav Vishnoi (2016) reviewed piezoelectric smart road sensors for energy harvesting from road vibrations.
- Debayan Paul and Anupam Roy (2015) discussed the viability of piezoelectricity as an alternative to fossil fuels for green energy harvesting.

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IV. OBJECTIVES

The primary objective of this project is to develop a renewable energy system using piezoelectric sensors to harness energy from vehicle movement.

The specific objectives include:

• Producing Renewable Energy to Overcome the Electricity Crisis
• Generating Electricity from Vehicles Using Piezoelectric Sensors
• Developing an Environmentally Friendly Energy Source

V. METHODOLOGY

The methodology employed in this project involves a systematic approach to design, construct, and test a piezoelectric energy harvesting system suitable for smart road applications. The following are subsections:

5.1 Piezoelectric Sensor Selection and Preparation

• Selection of Piezoelectric Material: Based on factors such as piezoelectric voltage constant, availability, cost-effectiveness, and sustainability, Lead Zirconate Titanate (PZT) and Quartz were chosen as the primary piezoelectric materials.
• Sensor Configuration: Piezoelectric elements were configured in a disc shape with a diameter of 20mm to maximize the surface area for pressure application.
• Wiring: Piezoelectric discs were wired in series to achieve a higher voltage output.

5.2 Experimental Setup Design

• Mechanical Stress Application: A mechanical setup was designed to simulate the pressure exerted by vehicles on the road surface. This setup included steel plates to distribute the load evenly, rubber padding to provide consistent contact, and springs to mimic the dynamic impact of vehicles.
• Energy Harvesting Circuit: The circuit was designed to capture andCondition the electrical energy generated by the piezoelectric sensors.
• Measurement Instruments: A multimeter was used to measure the voltage output from the piezoelectric sensors under various conditions.

5.3 Testing Procedure

• Baseline Measurement: Initial voltage output from the piezo cells was measured without any external pressure to establish a baseline.
• Single-Step Test: A controlled amount of pressure was applied to the piezo panels by a single step, and the resulting voltage was recorded.
• Multi-Step Test: Repeated steps were applied to the piezo panels to simulate continuous vehicle movement, and the voltage output was measured.
• Impact of Power Booster: The tests were conducted both with and without the voltage/power booster to analyze its effect on the energy output.
• Data Recording: The voltage measurements were recorded for each test condition to analyze and compare the energy generation.

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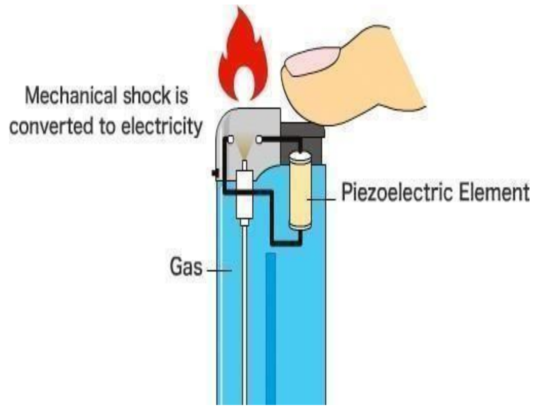
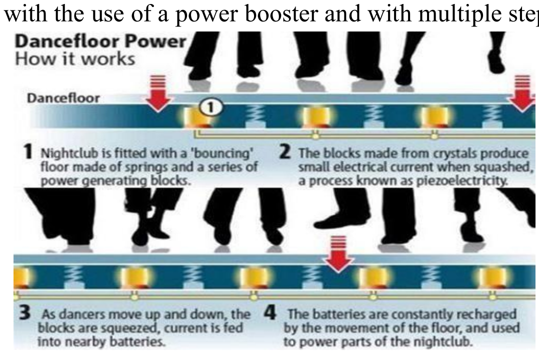


VI. EXPERIMENTAL OBSERVATION AND RESULTS

The materials used in the experimental setup include:

- Piezo cells
- Multimeter
- Voltage/Power booster
- Rubber
- Diode
- Zener diode
- Rechargeable batteries
- Steel plates
- Springs
- Copper wires
- Indication lights

Tests were conducted on piezo panels with and without a power booster to measure the voltage output. The results showed that the voltage output increased with the use of a power booster and with multiple steps on the piezo panels.



VII. ADVANTAGES OF PIEZO SMART

Roads

Piezoelectric smart roads offer several advantages:

- Renewable Energy Generation: They generate clean and renewable energy from existing infrastructure.
- Sustainable Infrastructure: They reduce reliance on fossil fuels.
- Cost Savings: They can potentially offset energy consumption of road infrastructure.
- Increased Efficiency: They improve energy efficiency by converting wasted mechanical energy.
- Infrastructure Monitoring:

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Embedded sensors provide real- time data on road conditions and traffic.
• Low Maintenance and Long Lifespan: Piezoelectric materials are durable and require minimal maintenance.

VIII. DISADVANTAGES OF PIEZO SMART ROADS

• Cost: Implementation can be expensive.
• Durability and Maintenance: Ensuring longevity under harsh conditions is challenging.
• Efficiency: Energy conversion may not be 100% efficient.
• Limited Energy Generation: Energy generated depends on traffic volume.
• Dependency on Vehicle Traffic: Energy generation is dependent on the presence of vehicles.
• Integration Challenges: Integrating into existing infrastructure can be complex.

IX. CONCLUSION

Piezoelectric roads have the potential to generate electricity from the mechanical strain produced by vehicles, providing a renewable energy source. They offer environmental benefits by reducing carbon emissions and contribute to innovation and technological advancement in transportation and renewable energy. Scalability and large-scale implementation will be critical for their widespread adoption.

REFERENCES

[1] Harper, Douglas "piezoelectric". Online Etymology Dictionary.
[2] Gautschi, G(2002), piezoelectric sensors; Force, Strain, Pressure, Acceleration and Acoustic emission sensors, Material and Amplifiers, Springer.
[3] Jacques and Pierre Curie Theory.
[4] Sergey V. Bogdanov. "The origin of piezoelectric effect on pyroelectric crystals."
[5] Senor sense: Piezo-electrtic Force sensors
[6] Ikeda,T.(1996). Fundamentals of piezoelectricity. Oxford university press.
[7] Pravin Wale, Chetna Patil, Aditya Thakare, Ajeta Vinchurkar, Purvi Pagare Generation of electricity from roads by using piezoelectric sensors (2021).
[8] Priyanka Baniya, Shivanjali Barge, Rahul Patil , Prof. Poonam Yewale Power Generation using Piezoelectric Material (2019)
[9] Abdul Fataha , Muhammad Mohsin Memonb , Lala Rukh Memon The piezo smart road (2018)
[10] Jaskaran kaur, abhinav vishnoi A review on piezoelectric smart road sensor (2016).
[11] Debayan Paul, Anupam Roy Piezoelectric Effect: Smart roads in green energy harvesting (2015).