

A CASE STUDY ON PIEZOELECTRIC ROAD IN KOLHAPUR CITY

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Abstract -The growing demand for electrical energy and the need for sustainable power sources have encouraged the development of alternative energy technologies. Piezoelectric road technology is an innovative approach that generates electrical energy from mechanical pressure produced by moving vehicles. In this study, an experimental setup was developed using piezoelectric sensors to analyze the generation of electrical energy under different loading conditions. Mechanical stress applied to the sensors produces electrical voltage through the piezoelectric effect. The generated voltage was measured using a multimeter to evaluate the performance of the system. The experimental results show that the output voltage increases with increasing applied load, indicating the feasibility of energy harvesting from traffic movement. Although the generated energy is relatively small, it can be utilized for low-power applications such as street lighting, traffic signals, and monitoring devices. The study demonstrates the potential of piezoelectric roads as a supplementary renewable energy source for future smart city infrastructure.

Key Words: Piezoelectric Road, Energy Harvesting, Piezoelectric Sensors, Traffic Load Energy Generation, Renewable Energy, Smart City Infrastructure.

1. INTRODUCTION

Energy demand is increasing rapidly due to urbanization, population growth, and the expansion of transportation systems. Conventional sources of energy such as coal, petroleum, and natural gas are limited and contribute significantly to environmental pollution. Therefore, the development of alternative and sustainable energy sources has become an important area of research.

Piezoelectric technology is an innovative method that converts mechanical energy into electrical energy using the piezoelectric effect. Certain materials have the ability to generate electrical charge when mechanical stress is applied to them. This property can be utilized in transportation infrastructure where continuous mechanical pressure is generated by moving vehicles.

When piezoelectric sensors are embedded beneath road surfaces, the pressure exerted by vehicle loads compresses the sensors and produces electrical energy. The generated electrical energy can be collected, rectified, and stored for various applications. Although the energy produced from a single sensor is small, a large number of sensors installed along busy roads can generate a significant amount of electrical energy.

This technology can be used to power low-energy devices such as street lighting, traffic signals, display boards, and monitoring systems. In addition, piezoelectric road systems support the concept of smart cities by utilizing existing road infrastructure for energy generation without additional fuel consumption.

The objective of this study is to analyze the feasibility of generating electrical energy using piezoelectric sensors under mechanical loading conditions and to evaluate its potential applications in road infrastructure systems.

2. Body of Paper

Literature Review

Many researchers have studied the use of piezoelectric materials for energy generation from road traffic. Piezoelectric sensors can convert mechanical pressure from moving vehicles into electrical energy. Previous studies show that the amount of energy generated depends on factors such as vehicle load, traffic density, and proper placement of sensors in the pavement. Researchers have also suggested that piezoelectric road systems can be used for low-power applications such as street lighting, traffic signals, and monitoring devices. However, challenges such as high installation cost, durability of sensors, and low energy conversion efficiency still limit large-scale implementation.

3. Methodology

The present study was carried out to analyse the feasibility of generating electrical energy using piezoelectric sensors under mechanical loading conditions. The methodology involved designing an experimental setup, installation of piezoelectric sensors, application of load, and measurement of the generated electrical output.

3.1 Experimental Model Development

A small-scale experimental model was developed to simulate the working condition of a piezoelectric road system. A rigid base platform was used to represent the road surface. Piezoelectric sensors were installed beneath the loading surface so that they could experience mechanical stress when load was applied. The arrangement of sensors was designed to capture the maximum pressure generated by the applied load.

3.2 Installation of Piezoelectric Sensors

Piezoelectric sensors were fixed securely beneath the loading platform and connected using electrical wires. The sensors were connected to a circuit consisting of connecting wires and measuring instruments. Proper insulation and connection were ensured so that the generated electrical signal could be measured accurately.

3.3 Application of Load

Different loads were applied to the experimental model to simulate the pressure produced by vehicles moving on the road. The load was gradually increased to observe the variation in electrical output. Each load condition was applied carefully to ensure uniform distribution of pressure on the sensors.

3.4 Measurement of Electrical Output

The electrical voltage generated by the piezoelectric sensors was measured using a digital multimeter. The readings were recorded for different loading conditions. The generated voltage indicates the conversion of mechanical stress into electrical energy through the piezoelectric effect.

3.5 Data Analysis

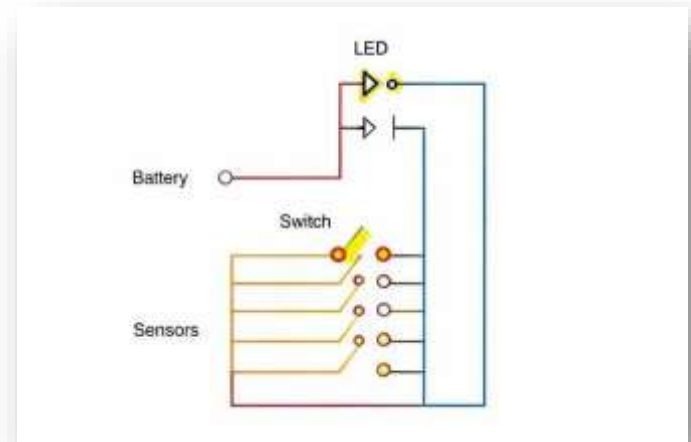
The collected data was analyzed to understand the relationship between applied load and generated electrical voltage. The results were compared for different loading conditions to evaluate the performance of the piezoelectric system. The observations help in determining the feasibility of using piezoelectric technology for energy harvesting from road traffic.

4. Study Area

The study is focused on the city of Kolhapur located in the state of Maharashtra, India. Kolhapur is a rapidly developing urban area with increasing transportation activity and traffic density. The city has a well-developed road network connecting residential, commercial, and industrial zones, which results in continuous movement of vehicles throughout the day.

Due to the constant traffic flow, large amounts of mechanical pressure are generated on road surfaces by moving vehicles. This pressure can be utilized for energy harvesting using piezoelectric technology. Busy roads, intersections, toll plazas, and traffic signals are considered suitable locations for implementing piezoelectric road systems because of the high vehicle frequency and repeated load application.

Kolhapur city was considered as a potential study area to analyze the feasibility of generating electrical energy from traffic movement using piezoelectric sensors. The concept can support sustainable development and smart city infrastructure by utilizing existing road systems for renewable energy generation.



Piezoelectric Sensors & Circuit Diagram



3. CONCLUSIONS

The study demonstrates that piezoelectric technology can be used to generate electrical energy from mechanical pressure produced by moving vehicles. When force is applied to piezoelectric sensors, electrical voltage is generated due to the piezoelectric effect. The experimental setup shows that the generated voltage increases with an increase in applied load.

Although the amount of energy produced by a single sensor is small, multiple sensors installed beneath road surfaces can generate a continuous supply of electrical energy. This energy can be used for low-power applications such as street lighting, traffic signals, and monitoring systems.

Piezoelectric road technology provides a renewable and environmentally friendly method of energy generation by utilizing the mechanical energy produced by traffic movement. With further improvements in sensor efficiency, material durability, and system design, this technology can contribute to sustainable infrastructure and smart city development in the future.

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