A Review on Alternative Energy Production - Energy Harvesting Using Piezoelectric Technology

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ABSTRACT
In this paper there is an attempt made to understand piezoelectric material is used in an enhanced way of energy harvesting. Piezoelectric materials can be used to convert mechanical energy, such as ambient vibration, into electrical energy, which can then be stored and used to power other devices. When mechanical stress is applied to a piezoelectric substance, it produces an electric charge. When an electric field is introduced, however, a mechanical deformation occurs. The electrical density generated by piezo-film can be stored in a rechargeable battery for later use. Piezoelectric materials offer a wide range of applications in real-world settings. The following are some of the most recent applications. Currently, alternate kinds of energy are required at passenger terminals such as airports and railways all over the world. To keep prices down, preserve friendly and productive relationships with neighbours, and ensure a healthy environment for future generations, cleaner, more sustainable kinds of electrical power are required. Currently, alternate kinds of energy are required at passenger terminals such as airports and railways all over the world. To keep prices down, preserve friendly and productive relationships with neighbours, and ensure a healthy environment for future generations, cleaner, more sustainable kinds of electrical power are required. Piezoelectric devices installed in terminals will allow kinetic energy from foot traffic to be captured. This energy can then be utilised to compensate for some of the electricity that is supplied by the main grid. Lighting systems can then be controlled using such a source of power.

Keywords: *PZT – piezoelectric technology, energy harvesting*

INTRODUCTION

In the contemporary period, when energy costs are increasing and fossil fuel reserves are rapidly depleting, there is a pressing need to find strategies for prudent energy use that also prioritize environmental protection. Energy harvesting is one of the new ways to accomplish this. Energy scavenging, also known as energy harvesting, is a method of capturing small amounts of energy that would otherwise be wasted as heat, light, sound, vibration, or movement.

It makes use of the energy it captures to increase efficiency and enable new technology, such as wireless sensor networks. Energy harvesting has the potential to eliminate the need for batteries in low-power electronic devices.[1,2]

Typically, an energy harvesting system has three parts

- Source of Energy: this is the energy that will be used to generate electrical power; it can be ambient (available in the ambient environment, such as sunlight, ambient heat, or wind) or external (energy sources that are specifically deployed, such as lightning, human heat, or wind).
- Harvesting energy is made up of a structure that turns ambient energy into electricity.

- Load that consumes or stores the electrical energy produced.

Sunlight, electromagnetic radiation, environmental mechanical energy, human body heat, and human body mechanical energy are the most common small-scale energy sources. Solar energy, electromagnetic radiation, and environmental mechanical energy are all strongly dependent on one other

Human body energy harvesters may be integrated into daily human activities to power a variety of devices, which is good for the environment.

The principle of thermoelectric power generators, which is based on the Seebeck effect of materials, can be used to harvest human body heat. The differential between the human body and the ambient temperature can be used to generate electrical energy utilising the principle of this substance. The drawback is that a significant temperature difference is required for a stable system.

Due to their abundance in daily life, human body mechanical energy and environmental mechanical energy are widely exploited. Every natural motion has the capacity to generate kinetic energy.

Mechanical energy is thus the most common form of energy. Sufficient power can be provided by mechanical energy scavenging to enable long-term autonomy for self-powered systems [1]. For example, upper-limb activity creates around 10 mW, typing motion generates 1 mW, breathing generates approximately 100 mW, and walking generates up to 1 W. For mechanical e, the harvested power density P depends on motion frequency and magnitude, as shown in the resonance power Formula

$$P_{res} = 4\pi^3 m f_{res}^3 y Z_{max}$$

where m is the inertial mass, Zmax is the maximum displacement, fres is the resonance frequency, and y is the amplitude of vibration of the housing, the approximate working-frequency level for different mechanical energy sources is shown as below. [3,4]

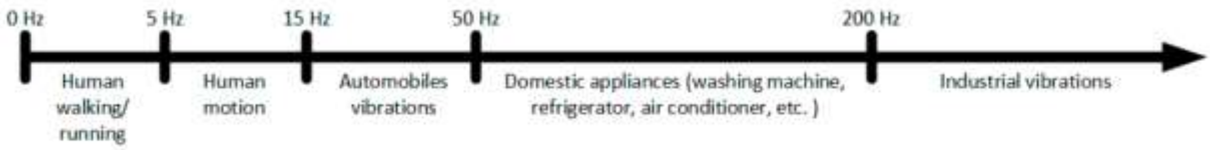

Fig. 1: *Different Mechanical Energy Sources – Frequencies.*

Electromagnetic, electrostatic/triboelectric, and piezoelectric are three common methods for converting mechanical energy into electrical energy. If the mechanical-to-electrical energy conversion efficiency is high, when data transport is required, electromagnetic systems are the best choice because coils are commonly used and magnets, but this also entails large, complex machinery. The decision between the applications of these three technologies is considerably dependant on the application, however piezoelectricity is the most often used.

If the application necessitates a high voltage, high energy density, large capacitance, and minimal mechanical complexity, with the insight that piezoelectric energy harvesting is the solution to damping, Materials can be fragile or rigid, and they can also be hazardous. For applications that don't require access to the internet.

Electromagnetic devices, rather than piezoelectric transducers, can be utilised as sources.

To accomplish the desired spinning velocity, speed growth gears are added due to the power demand. Electromagnetic devices, as a result, are incompatible with microscale fabrication suitable for human body applications. When compared to piezoelectric and electromagnetic energy harvesting, triboelectric energy harvesting has a number of benefits, including high power density, high conversion, and device flexibility.

It still has issues with reliability and durability, and its working mechanism isn't completely understood. Each energy harvesting method has benefits and drawbacks, and many approaches for properly harvesting energy from human body motion have been proposed in the literature.

The focus of this review will be on piezoelectricity and piezoelectric energy harvesting technologies.

ENERGY HARVESTING FROM AIRPORT RUNWAYS OR ROADWAYS

The practice of obtaining energy from the environment that would otherwise be squandered and transforming it into usable electric energy is known as power harvesting. It is particularly important to develop environmentally friendly and renewable energy sources.

If correctly harnessed, piezoelectricity has the potential to offer us with a great source of green energy. Scientists are hard at work trying to figure out how to capture piezoelectric energy in the most efficient way possible. It is thought that by placing piezoelectric materials beneath busy highways, it will be feasible to generate power from the vibration energy of passing cars.

This technology, known as parasitic energy harvesting, is now being investigated on a limited scale, with a typical 4-lane highway producing roughly 2 megawatts of power per kilometer of roadway. The device might also be used to harvest energy from runways and rail systems at airports.

In reality, around 25 square metres of piezoelectric flooring are currently installed in the Tokyo subway system. The station's flooring generates roughly 1400 kilowatts of electricity each second, enough to power the system's ticket gates as well as electric lights and displays. Figure 2 depicts the generation of power from airport runways during a plane's landing.

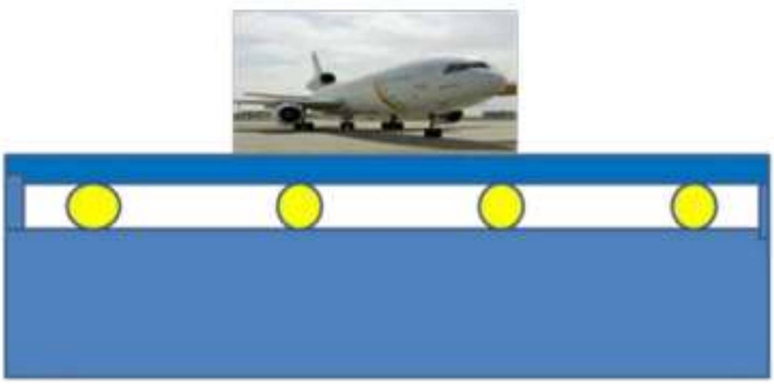

Fig. 2: *An artistic view of electricity generation from airport runways during Landing of an aeroplane.*

Haim Abramovich has created Innowattech Ltd, a start-up firm that manufactures and distributes Innowattech Piezo Electric Generators (IPEG). A schematic representation of an Innowattech Piezo Electric Generator is shown in Figure 3. Weight, motion, vibration, and temperature changes can all be used to power these generators. That is, highways, railways, and airports may all be used to produce high-efficiency generators. IPEG entails wrapping a narrow box around the piezoelectric material and placing it beneath a layer of asphalt. When a car drives over the box, the vertical force compresses the piezoelectric material, causing energy to be generated.

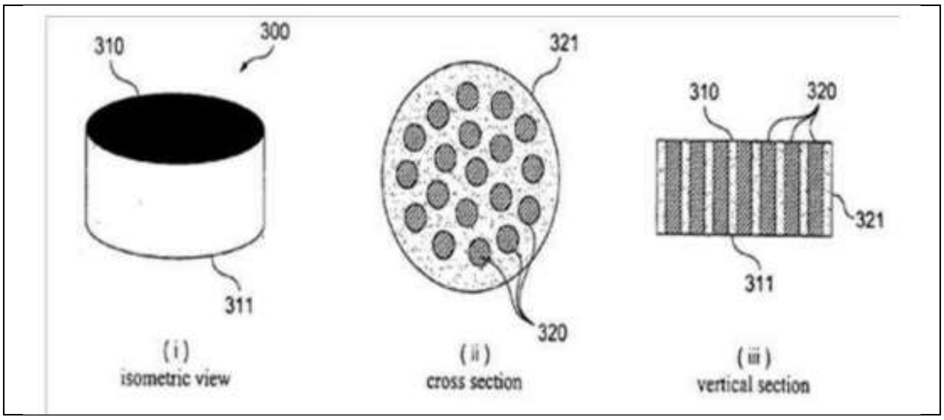

Fig. 3: *Schematic Diagram of Innowattech Piezo lectric Generator.*

It's worth noting that Abramovich and his colleagues conducted genuine experiments on generating electricity from roads. They constructed a 100-meter stretch of road with a huge number of IPEGs embedded in it.

The distance between neighbouring IPEGs was 30 cm, and the IPEGs were embedded 6 cm below road surface. Extrapolating from these trial trials, a 1 km length of road would create around 400 kWh of power if 600 vehicles (each weight 5 tonnes) passed through in an hour. This amount of energy can power 600 to 800 houses.

According to Wafi Danesh, one can create 8138 kWh of energy from 109 landings or takeoffs of A380 aeroplanes (weight 560 tonnes) per hour on an airport runway So far, so good. There are no highways or runways that could be utilised for this purpose. Generating electricity from moving cars and planes in a consistent manner The topic is still in its early stages.

Energy Harvesting Through Shoes

Walking pressure can be transformed into electrical energy, which can be used to power portable electronics. A moonieharvester]is embedded into a shoe to accomplish this. A poled lead zirconatetitanate (PZT) ceramic is sandwiched between two specially engineered metal end caps to create the "Moonie," a metal ceramic composite transducer. Figure 3 also depicts the moonie harvester's working principle.

The structure acts as an amplifier for the input force, which is the weight of the person wearing the shoe in this example. The force on the heel presses the curved plates, causing the piezoelectric disc sandwiched between the steel plates to expand.

In contrast to beam structures, where the majority of the stress is concentrated at the fixed end of the beam, the tension on the disc is evenly distributed.

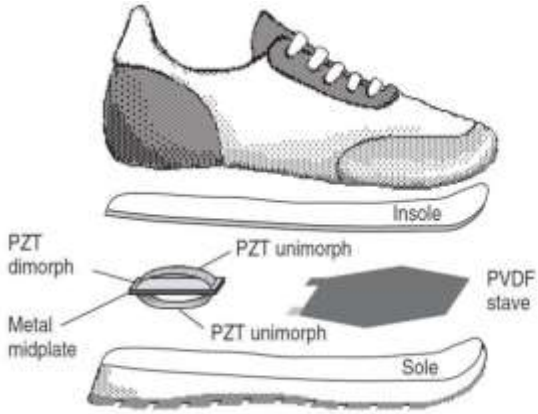

Fig. 4: *PZT Shoe.*

When walking 2 steps per second, the energy production of one step was measured at 81 J, which equates to 162 W for two shoes. At a frequency of 1 step/s, the power density was measured to be 56 W/cm3. The piezo element measured 17.5 mm in diameter and 500 mm in thickness. PZT-5H was employed as the material.

CONCLUSION

Over the last two decades, piezoelectric energy harvesting has grown into a huge field of study.

Although it is difficult to synthesise all of the work published in this field over the last decade, this article aims to provide a succinct synopsis of the most influential studies published since our original review article in 2007. We hope that this article was able to adequately convey the recent growth of the field of piezoelectric energy harvesting, as well as recognise the various research groups working in this fascinating field. We also believe that this article, when combined with our initial review article, will be a beneficial resource for both current and future researchers interested in piezoelectric energy harvesting.

Single crystals, lead-free piezoelectrics, high-temperature piezoelectrics, piezoelectret foams, and piezoelectric nanocomposites have all been introduced as a result of the ongoing development of new piezoelectric materials with improved electromechanical, mechanical, thermal, and biocompatible properties. While traditional linear, beam-based piezoelectric transducers are still frequently utilised, the introduction of nonlinear and broadband harvesters has increased the frequency and power generating capabilities of piezoelectric devices. These new materials and transducers have been widely used in the development of application-based devices that harvest energy from fluid flow, the human body, animals, infrastructure, and automobiles.

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