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Railway Track Power Generation System Using Piezoelectric Material

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Abstract: This paper describes the way to generate electricity by the help of railway track vibrations caused by the motion of train. Piezoelectric transducers are used for the conversion of mechanical vibrations into electrical power, which are embedded beneath the railway track. This research describes the generation of power without using any fuel input, thus it is an eco-friendly power generation along with a source of non-conventional power source. In today life use of non-conventional energy sources are very much essential in order to protect our environment from pollution and save the limited conventional energy source. This idea is very useful for signaling purpose, where conventional power is difficult to reach. The concept of piezoelectric effect is very useful to this modern world in different fields like voltage & power source, sensors, piezoelectric motors, actuators, reduction of vibrations and noise, frequency standard, surgical procedure**,** photovoltaic etc.

Keywords: Piezoelectric material; Piezoelectricity; Non-Conventional power; railway track vibration

Introduction

Human need never ends. When requirement can't be fulfilled by available resources, then development or innovation will come. We have used the conventional energy for long days. Due to which, we are facing two main problems; one is environment pollution and another is the threat of disappearing the conventional energy source. That's why we are trying to utilize and explore new non-conventional source of energy, as these energy sources don't affect the environment and also non-perishable. The main sources of non-conventional energy are; geothermal, solar energy, tidal power, biofuel, hydropower, biomass, wind power, wave power, etc. Now researches is also going on to find more source of non-conventional energy, as there is a large importance of non-conventional energy to our world.

Piezoelectricity is a type of electrical charge that accumulates in some certain types of solid material in response to the applied pressure. The name piezoelectricity means electricity produced from pressure. When pressure is applied, the piezoelectric crystal becomes a type of small battery with one face positive charge and other face negative charge. And the current flow starts when the two faces are connected to make a circuit. Some common piezoelectric materials are Quartz, Berlinite, Topaz, Sucrose, Tourmaline-group minerals, Rochelle salt, Topaz , Lead titanate etc. The proper choice of the piezoelectric material is the principal importance. In reverse process, when a voltage is applied across the opposite faces of piezoelectric material, the crystal becomes mechanically stressed or deformed. From research it has been found that the voltage from a series connection of piezoelectric materiel, is superior but the current obtained is poor. Where as in parallel connection the current is superior but the voltage is poor. This problem can be rectified in a series- parallel connection, where we can get appreciable voltage as well as current (Kiran et al., 2014) [1].

Curie and Curie (1880) discovered the piezoelectric effect. Piezoelectric material creates voltage when pressure is applied and vice-versa. Piezoelectric materials are may be naturally occurring or man-made [2]. Funasaka et al. (1998) studied PEG in two devices in one with lead zirconate titanate (PZT) and in other lithium niobate (LiNbO3). They found LiNbO3 have higher conversion efficiency than PZTI (conventional material) [3]. Ramsey and Clark (2009) used a rounded thin-plate transducer and a piezoelectric element with a 31 poling direction to collect energy from blood pressure fluctuations and they were able to get 2.5 μW power. As the force or fluctuations were relatively small these results couldn't be generalized [4]. Dong et al. (2004) found that a strong magneto-electric voltage gain effect has been found in laminate composites of piezoelectric PZT and magneto-strictive Terfenol-D. And he believed that those results were important for uses in miniature solid-state power transformers [5].

Ogando (2007) investigated several uses of vibration regulator technology. The area of adaptronics consist of more than piezoelectrics and play a very important role. He told that, for vibration control structure, adaptronics actuators can be planned to address a wide range of frequencies from 50HZ to 1000 Hz, depending on the application requirements [6]. Anil Kumar (2011) found that use of double actuators in parallel connection can decrease the charging time of the battery and can enhance the power generation by the piezoelectric means [7].

JAGDALE et al. (2016) attempted method of generating energy in a fast moving vehicle and suggested for utilization of wind energy produced by trains for generation of electricity [8]. Yang et al. (2018) used a Piezoelectric energy harvester (PEH) to alter the automated energy of automobiles into electrical energy [9]. Elhalwagy et al. (2017) addressed an idea to get maximum benefits from piezoelectric energy harvesting floor in buildings [10]. Laumann et al. (2017) proposed a decision making model including requirement for better understanding of niches and structure of energy harvesting design concerns [11]. Papagiannakis et al. (2016) developed an energy collecting system based on piezoelectric materials inserted into the pavements structure [12]. Gao et al. (2017) developed a prototype for smart monitoring and powering rail-side devices in off-grid and remote areas by local energy generation [13].

Sil et al. (2017) discussed an effective method to cater the energy needs of transportable electronics, improvement in the field of power harvesting and presented the current state of power harvesting to produce completely auto-powered devices [14]. Najini and Muthukumaraswamy (2017), presented a technical simulation by MATLAB Simulink to support the concept of generating energy from road traffic using piezoelectric materials [15]. Bulbul et al. (2017), described a suitable methodology required for generation of electricity from piezoelectric materials. An integrated HESSs is also implanted for storing of energy in a reliant way [16]. Bradai et al. (2018), proposed a prototype for electromagnetic vibration conversion by considering the real vibration constraints, robustness and integrability requirements, which is based on a moving coil connected to a mechanical spring [17]. Xiaochen et al. (2018), have shown that utilization of piezoelectric technology in road energy harvesting is feasible and has a bright future in the coming time [18].

Working Principle

Piezoelectricity effect occurs when mechanical pressure is applied to certain materials like Quartz, Berlinite etc. If we squeeze these crystals then, electricity will flow through them. The reverse is also true; if we apply electricity to these crystals then it will squeeze itself by vibrating back and forth. When we apply pressure, an electrical polarization is set up in the crystal which consequences the faces to be electrically charged. The charge will reverse if the compression changes to tension. This piezoelectric stresses are similar to electrical voltage in solids. The piezoelectric effect only occurs in non-conductive materials.

Experimentation

In this present experiment piezoelectric devices used to generate electricity. A model of railway track as shown in figure 1 is used for this experiment. Piezoelectric transducers placed in the rail roadbed under the track structure. It can be also places on side of railway track. When the train passes on the rail track, it vibrates and creates pressure on this placed piezoelectric transducer. And the piezoelectric transducers change the applied pressure into electricity. Amount of electricity varies based on the number of transducers placed.

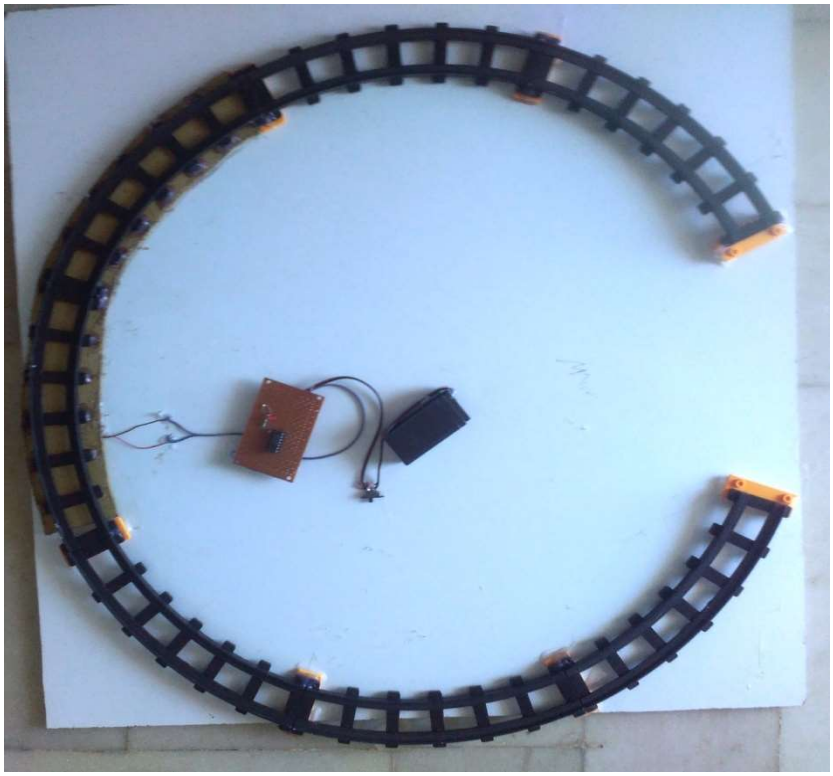

Fig. 1: Model of railway track with Piezoelectric transducers

Because of the vibrations caused by the momentum of train the piezoelectric sensors are actuated and generate a fluctuating potential difference. Sensors are further joined to the amplifier for amplification of input signal (as shown in figure 2). And then this is connected to battery along with a parallel led of lightning purpose.

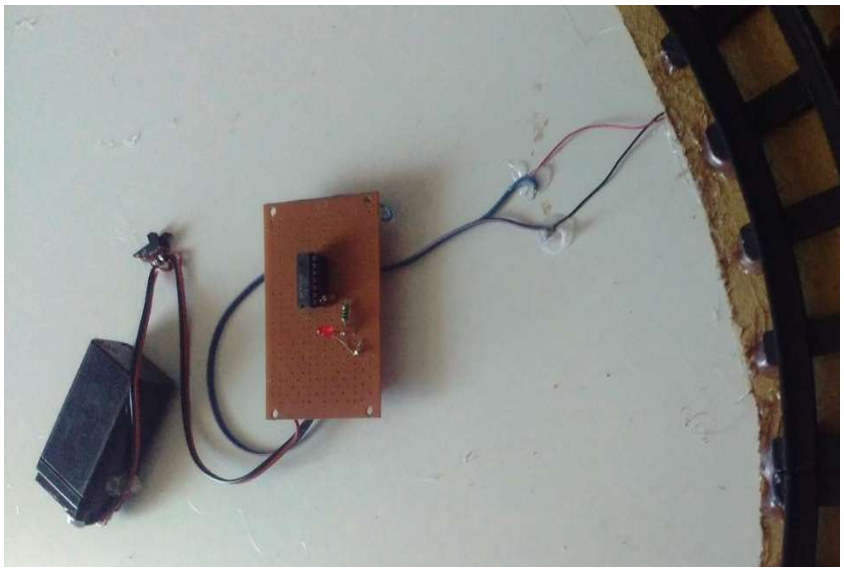

Fig. 2: piezoelectric sensors with amplifier for amplification

Conclusions

The voltage generated in this research is small but acceptable for lightening purpose. This voltage could be used for other applications such as railway traffic signaling in rural or remote areas where installation cost is very high. Here piezoelectric transducers are used in railway track, which shows idea to use this in the wheel of train, so that some electricity can be generated for lightening inside the train and mobile charging etc. This technique can also be used for computer or mobile charging by attaching the keyboard with the piezoelectric material. This technique can also be used for charging of mobile or small instrument while moving in vehicle, by placing the piezoelectric material below the seat. This technique can be used in several applications with some modification.

In light of rising demand of clean energy or non-traditional energy, this research "Railway Track Power Generation Using Piezoelectric Material" can be of great advantage. Research adjoining this may lead to latest sources for energy harvesting, which can save traditional energy and protect our environment.

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