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Piezoelectric Energy Generation from Vehicle Traffic

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ABSTRACT
This paper presents a system to support the concept of generating energy from road traffic using piezoelectric materials. The system design structure was proposed considering factors involved with the field of material sciences for piezoelectric generator modeling and field of power electronics for additional components in producing a realist outcome.
It also ensures ease of vehicle performance, as this system utilizes energy source derived as kinetic energy released from vehicles into electrical power output, that is, obtained by harnessing kinetic energy due to strain of vehicles over asphalt road surface.
Due to the real-time simulation platform, the system simulation predicts the effective global carbon footprint. This is followed by a comparative study with other sources of renewable energy based on levelized energy cost factor that justifies the performance of the proposed system over other renewable energy sources, in support of providing an economical solution on reducing global carbon footprint.

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I. INTRODUCTION

At present, electricity has become a lifeline for human population. Its demand is increasing day by day. Modern technology needs a huge amount of electrical power for its various operations. With the rapid devlopment of society, the increasing energy consumption leads to the shortage of nonrenewable energy resources. To solve this problem, many countries pay attention to the collection and use of renewable energy. Great mechanical energy is wasted during this process. It will be a break through for energy conservation and emission reduction if the mechanical vibration energy is transformed into electric energy.

UseHarvesting of energy which means energy is already availabo but is going to waste if not utilized. we have to think something new. We have to think of non renewable source of energy. In this new way of power generation can be done as there is no power from the main and there is no pollutions from this source of energy.

II. METHODOLOGY

The proposed work is planned to be carried out in the following manner
* WHAT IS THE PIEZOELECTRIC TRANSDUCER
1.Piezo is derived from Greek word ⍰piezein⍰ which mean press.
2.Piezoelectric effect was discovered by Pierre Curie in 1880 in quartz crystal.
3.A transducer converts one form of energy into another.
4. In the case of a piezoelectric transducer the transduction is from mechanical energy to electrical energy and vice versa.

The piezoelectric transducers work on the principle of PIEZOELECTRIC EFFECT. When mechanical stress or forces are applied to some materials along certain planes, they produce electric voltage. This electric voltage can be measured easily by the voltage measuring instruments.

Properties used for piezoelectric transducer

There are various materials that exhibit piezoelectric effec. But it should posses desirable properties like.

1.Stability
2.high output
3.insensitive to the extreme temperature and humidity and
ability to be formed or machined into any shape.

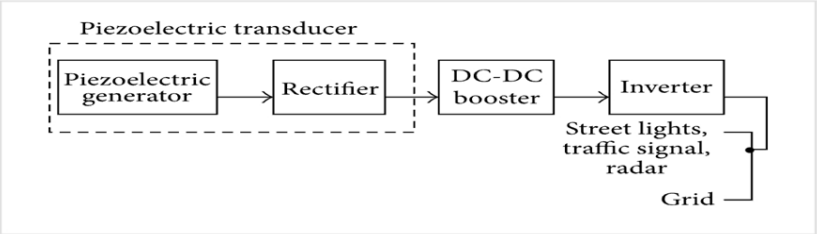
Materials are used in piezoelectric transducer

Barium Titanate.
Lead zirconate titanate (PZT).
Rochelle salt.
Quartz

III. MODELING AND ANALYSIS

This methodology is ideal for developed countries as the installation process requires revenue and the power generation is high voltage which requires proper transmission installation. First, a basic block design for this type was structured depicted by Figure.

BLOCK DIAGRAM



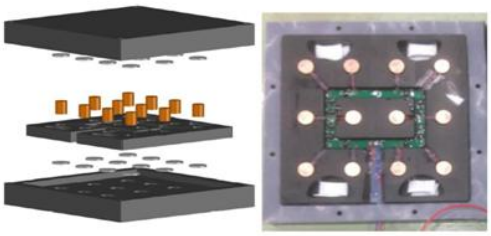


Fig. 1. The inner structure of the PEH.

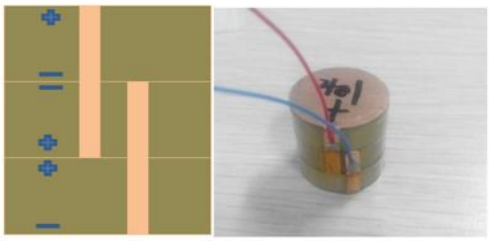


Fig. 2. The piezoelectric unit.

The flow chart shown in Figure represents the working process of the entire proposed system. From literature review, the system comprises a piezoelectric transducer that is to be embedded within the surface of the road at 5 cms below the surface as per studies.

These piezoelectric transducers capture the strain due to the mass of the vehicles, the kinetic energy due to moving traffic, and the vibrations caused due to the contact between the tire and the asphalt road surface as its input source of energy. The piezoelectric generator block then converts this input mechanical input (strain) energy source into electrical power output (AC power generation). Then this power is rectified into DC power source via the rectifier block.

Then the rectified output from the piezoelectric generator as seen from fig. is doubled via DC boost converter system for the purpose of transmission. Next, the power produced is passed through the inverter block as indicated in Figure that produces AC power output before supplying it to grid for further transmission.

Design of PEH for asphalt road

* Piezoelectric energy harvesting technique is to use a Piezoelectric Energy Harvester (PEH) to convert the mechanical energy of vehicles into electrical energy. the PEH must have good compressive ability, fatigue resistance, waterproof and anti-corrosion performance.
* Considering the contact area of tires, the PEH was designed to be 30 cm wide and 30 cm long. PEHs in such dimension will have better contact with the wheels of traveling vehicles. The thickness of the PEH is 8 cm.
The PEH consists of 12 piezoelectric units, an internal rectification circuit, and two power output cables. Other than a rectangular PEH, a circular

PEH was also fabricated with diameter of 30 cm and a height of 8 cm, containing 12 piezoelectric units.
* The PEH consists of four parts: the piezoelectric units, the packaging materials, the internal circuit boards and other sealing fastening components. The inner structure of the PEH is shown in Fig.
*After connecting each of the piezoelectric units to the circuit board, the power output will be rectified and extracted by the cable. The rectifier bridge is sealed with electronic glue to prevent the short circuit caused by water leakage

Fig. 6. The installation process of the PEH.

* PEH installation process includes the following steps
(as shown in Fig. 6):
1) Determining the position of each PEH
2) Cutting road surface
3) Core-taking, dressing pit,
4) Installing the PEH
5) laying the cable and filling the seam.

IV. RESULTS AND DISCUSSION

As the speed of vehicle increases, the open circuit voltage of embedded PEHs will rise, and more electric energy is produced. The open circuit voltage ranges between 250 and 400 V when the Toyota Highlander SUV passes the embedded PEHs at the speed between 20 km/h and 80 km/h.

According to reports, when traffic volume of vehicles is more than 500 in the single lane per hour, up to 250 kW of electrical energy can be collected per kilometer per lane.

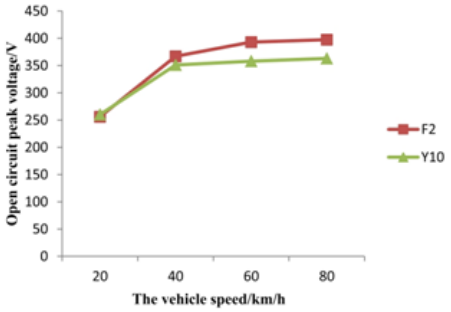


Fig. 8. The open circuit peak voltage of F2 and Y10 at different speeds.

* The PEH had an excellent power generating performance. The open circuit voltage generated from the PEH under the actual road traffic conditions was higher than 250 V. The output voltage was sensitive to the vehicle speed and increases with the increase in speed.

V. CONCLUSION

In this paper, a PEH (piezoelectric energy harvester) is developed to convert the mechanical energy wasted by traveling vehicles into electric energy. The PEHs were install in the pavement of a test site, and the performance of the PEH was evaluated under the real traffic loading. The PEH had an excellent power generating performance. The output voltage was sensitive to the vehicle speed and increases with the increase in speed. The energy collected by the PEH derived from the passed vehicle□s and the electric energy was ultimately supplied to the road facilities, which was in accordance with the concept of sustainable development.

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