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Piezoelectric Energy Generation from Vehicle Traffic

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Abstract - *This paper presents a technical simulation based system to support the concept of generating energy from road traffic using piezoelectric materials. The simulation based system design replicates a real life system implementation. It investigates practicality and feasibility using a real-time simulation platform.*

Here, the basic idea is to extract as possible maximum efficiency and proper sustainable use of piezoelectricity with the advancement of day-night sensor.

Here, a plan is made for electrification of street lights using piezoelectric sensors. It can generate enough electricity for consumption by street lights where any other power source is not available. At first, the piezoelectric sensors are placed on the highways and connected serially. The electrical energy is reused for charging of the battery. When vehicles will pass over the crystal, mechanical stress will be produced which in turn will generate an AC voltage. The voltage generated at the output due to pressure applied by vehicle is fed to the step down transformer because we are using 12V battery.

Basically, the electrification in this country is facing a lot of problem and is a growing matter of concern for all. Taking in account, the present source of energy it is difficult to make the electricity available for lightening of highway in night. To overcome this drawback we can utilize renewable sources of energy which are cost effective. There is loss of fuel and energy when vehicles are in motion on a highway. We can generate voltage by the pressure of these vehicles using piezoelectric effect. This voltage can be stored in battery and electrify a small belt of street lights.

Key Words: Piezoelectricity, Energy harvesting, Piezoelectric effect, Charge Storage, Bridge rectifier

1. INTRODUCTION

Piezoelectricity was present ever since mid-18th century. The prefix piezo is a Greek word which means 'press' or 'squeeze'. A piezoelectric substance is one that produces an electric charge when a mechanical stress is applied (the substance is squeezed or stretched).

Piezoelectricity is the electric charge that accumulates in certain solid materials (such as crystals, certain ceramics, and biological matter such as bone, DNA and various proteins) in response to applied mechanical stress. The word **piezoelectricity** means electricity resulting from pressure and latent heat.

The first experimental demonstration of a connection between macroscopic piezoelectric phenomena and crystallographic structure was published in 1880 by Pierre and Jacques Curie. Their experiment consisted of a conclusive measurement of surface charges appearing on specially prepared crystals (tourmaline, quartz, topaz, cane sugar and Rochelle salt among them) which were subjected to mechanical stress. These results were a credit to the Curies' imagination and perseverance, considering that they were obtained with nothing more than tinfoil, glue, wire, magnets and a jeweler's saw.

The commercial success of the Japanese efforts has attracted the attention of industry in many other nations and spurred a new effort to develop successful piezo-ceramic products. If you have any doubts about this, just track the number of piezo patents granted by the U.S. Patent Office every year - there has been a phenomenal rise. Another measure of activity is the rate and origin of article publication in the piezo materials/applications area - there has been a large increase in publication rate in Russia, China and India.

2. LITERATURE SURVEY

The phenomenon of Piezoelectricity was discovered in 19th century and in the 1880, Pierre and Jacques Curie performed the initial experiment and demonstrated the link amid the macroscopic piezoelectric phenomena and crystallographic structure. Their experiment consisting the certain measurements of charges appeared on the surface of crystals made up of quartz, tourmaline and Rochelle salt especially when the mechanical force was applied on them [1].

In almost every country, a huge number of people come to and go out from the train stations through the whole day or night. Therefore, all the roads near the stations remain always busy by various heavy and light weighted transport vehicles. Putting piezo electric materials in these roads, we can generate green electricity and supply it to the station [2].

In a research project supported by the National Science Foundation of China, they proposed a roadway reaper that utilizes piezoelectric harvesting units for searching energy from movement-instigated vibrations. The proposed roadway vitality reaper is a pressure based framework, which produces vitality under pressure drive, and the created control is a heartbeat control enlisted with every pressure cycle. Fig. 6 demonstrates the side cross-sectional perspective of the proposed roadway reaper installed on the surface of the street, Fleft and Fright are utilized to display the tire powers caused by one single pivot of an auto [3].

The number of experimental tests reported in the literature provides substantive information on the real-time electricity production from piezoelectric sensors. In the road energy harvesting systems, piezoelectric sensors are embedded in the pavement structure. The sensors are designed to harvest mechanical stresses and strains, which are then converted into electrical voltage. The output voltage depends on the traffic loading, the frequency of vehicles passing, and the vehicle moving speed. In conditions of dense traffic, there is a capability to reach electricity production at an industrial scale [4].

Also, during the following years ending to 1910, an extensive research had carried out to obtain a complete & detailed framework defining 20 classes of natural crystal and amongst them the occurrence of piezo-electric effect observed and explained the complete 18 suitable macroscopic piezo-electric coefficients accompanied by an energetic thermodynamic treatment for the solid crystals using suitable tonsorial analysis [5].

The "Sonar" was the first piezo-electric application developed in the era of World War-I. Paul Langevin and his colleagues invented the ultrasonic submarine detector in France during 1917. A transducer was contained in the detector manufactured with a slim quartz material stuck between the two steel plates with very high attention and reflected echo was detached with a hydrophone [6].

2.1 Conclusions Drawn from Literature Review

Following conclusions were drawn from the literature:-

- In future, Piezoelectricity might become a very useful source in reducing the energy crisis to a great extent.
- Some of the fields in which we can use piezoelectricity are the street lights, which are sourced by the pressure exerted by the moving vehicles onto the piezoelectric material installed for lighting.
- It can also be used to power the sign boards.
- The busy roads and airports can also be the specified areas for the installation for the piezoelectric material for harnessing the electrical energy for various uses.

3. GAP OBSERVED

The existing models made earlier failed to produce the optimum electricity when used in the railway stations. The usage was limited which has been up to a certain level.

At a time when governments are finding it hard to make land available for new power-plants, extracting energy while using the vast spread of highways all over the world seems no less lucrative proposition.

Table -1: Without Load

S.No.	Conditions of Vehicles Without Load	A.C. Output Voltage
01.	02 Wheeler	50
02.	04 Wheeler	600
03.	06 Wheeler	8335
04.	10 Wheeler	10670
05.	14 Wheeler	12335

Table -2: With Load

S.No.	Conditions of Vehicles With Load	A.C. Output Voltage
01.	2 Wheeler	90
02.	04 Wheeler	800
03.	06 Wheeler	13670
04.	10 Wheeler	18670
05.	14 Wheeler	22335

4. PROPOSED METHODOLOGY

Here, a plan is made for electrification of street lights using piezoelectric sensors. It can generate enough electricity for consumption by street lights where any other power source is not available. At first, the piezoelectric sensors are placed on the highways and connected serially. The electrical energy is reused for charging of the battery. When vehicles will pass over the crystal, mechanical stress will be produced which in turn will generate an AC voltage. The voltage generated at the output due to pressure applied by vehicle is fed to the step down transformer because we are using 12V battery.

From transformer, it is fed to bridge rectifier circuit to convert generated A.C voltage to D.C voltage. D.C voltage is passed through a diode to stop the backflow of the voltage signal. Then the D.C voltage is stored in the rechargeable battery. Battery is connected to a 3 phase transformer which will supply electricity to rural areas. Experimental data shows that applying 80 gram force to the tip of the crystal at a frequency of 60Hz produces an open circuit voltage of 13V peak between the two electrical leads. The output at the load is 5.3 VRMS, representing a power output of 3.6mW. If we take this value as reference then 300Kg of weight will produce 100 V peak to peak voltage and 1 Ampere of current which can easily charge a 12V battery.

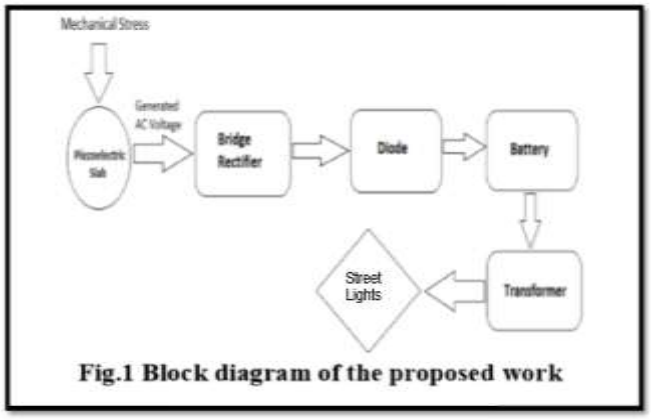

Fig.1 Block diagram of the proposed work

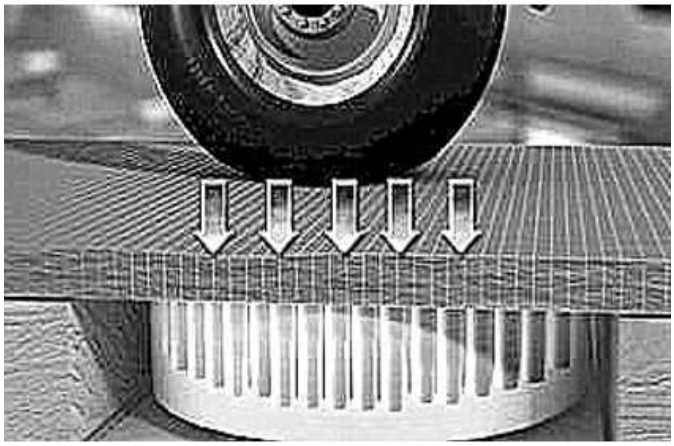

Fig. 02: Piezoelectric slab

4.1. Calculations

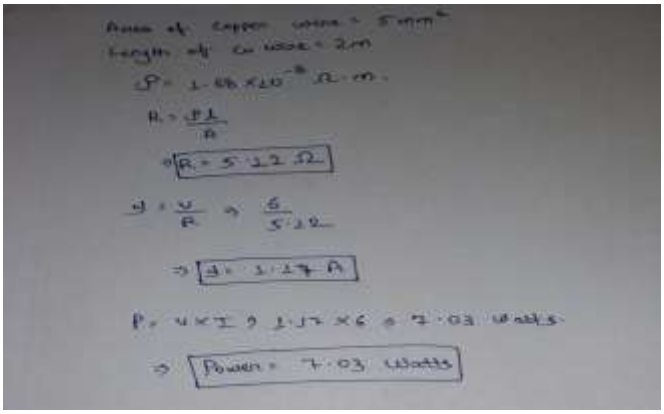

Fig -1: Calculation of Power

5. CONCLUSIONS

On the whole, the project is mainly focused on generating enough electricity by making use of piezoelectric materials for the electrification of street lights on highways.

It can also be used to power the sign boards. The busy roads and airports can also be the specified areas for the installation for the piezoelectric material for harnessing the electrical energy for various uses.

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