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Design of Energy Capturing Floor using Piezo Electric Energy Harvesting Technique for Generation of Electricity

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ABSTRACT

Piezoelectric materials offer a promising approach to reduce our dependence on conventional source of electricity. Crowd Farming can be a useful technique to extract power from piezoelectric materials. In our work, calculation have been made based on piezoelectric flooring system in crowded area, as the source of pressure is the footsteps of the crowd. Further from the literature study on piezoelectricity, one footstep can provide electrical energy to light two 60-watt bulbs for one second and the effect of large number of people on piezoelectric floor can generate electricity of substantial quantity.

Introduction

Several research works have been reviewed to understand and analyze the potential of piezoelectric generation using pressure exerted from people's movement. In United States, Defense Advance Research Project Agency (DARPA) initialized a project on energy harvesting which powers battlefield equipment by piezoelectric generators placed or constructed in soldier's boots or shoes. Though energy harvesting method affects the human body to a little extent, its efficiency to produce 1 to 2 watts from continuous shoe impact cannot be ignored. Kaajakari [1] et al (2010) conducted the same study in Micro structured piezoelectric shoe power generator which outperforms battery. Mandal [2] et al (2010) conducted a study on renewable energy source using piezoelectric effect to generate energy.

The piezoelectric crystals are placed beneath the pavements, sidewalks and high traffic areas like national highways, speed breakers to generate maximum differential voltage. The electric potential thus generated from the crystals can be used to charge the batteries (namely lithium batteries), capacitors. Research is also carried out to analyze the utilization of piezoelectric crystals by placing them under the keys of a mobile unit and keyboards. With the press on the key, the vibrations created by piezoelectric crystal can be used for charging purpose.

Arjun [3] et al (2011) conducted the same study using microcontroller to study the recycling of energy using piezoelectric crystals. Another research is to embed the piezoelectric crystals in the machines at gymnasium for utilizing the vibrations caused by the machines during work outs. At workplaces, while sitting on the chair, energy can be stored in the batteries by placing piezoelectric crystals in the chair. Experiments are being carried out for collecting the vibrations in vehicles, like at clutches, gears, seats, shock-ups, and foot rests. Though it is an efficient idea, implementation is difficult task in this case.

In Europe, certain nightclubs have already begun to power their night clubs by using electricity generated by piezoelectric crystals which are embedded in the dance floor. The When people use this floor, huge amount of voltage is generated which can be used to power the equipments at the night club.

Background

Piezoelectricity is process of development of electric source using piezoelectric effect. The basic idea is derived from the principle of piezoelectric effect. In present world, we are most commonly using conventional source of energy to produce electric source which is depleting day by day.

Hence there is a need to switch on to non-conventional source of electrical energy like wind energy, solar energy, biomass energy, hydro-electric energy. On these lines, piezoelectric flooring technique is more efficient and is of lower cost in implementation and requires less maintenance. This technique is efficient in producing electric source in various forms and different methodologies can be used at all extents.

Methodology

The basic methodology followed in this study involves the piezoelectric crystals, which gets pressurized with the help of gravitational force and the pressure exerted by the people movement. This energy captured from the crystals is stored in the form of voltage. The crystal generates alternate form of current waves (A.C.) as the movement over the floor is not uniform. The alternate source of electrical energy is converted to direct current using rectifier circuits. Later the converted current is stored in the capacitors. The capacitor smoothly supplies the current to charge battery and other small purposes. The top layer is to be strong part (i.e. made up of hard, elastic material), the middle portion is rubber coated one where the rubber makes the pressurized impression over the crystal. And the bottom layer is arranged with piezoelectric crystals. It is ensured that the flooring system resists the effect of wear and tear and no generation of inverse Piezo electric effect. As piezocrystals and the setup readily available at a lower cost, the system can be easily implemented.

Numerical Studies

Statistical survey of railway stations

Most of the railways stations in Chennai city are crowded in the morning and evening peak hours. A survey was undertaken in the important railway stations to study the crowd effect and quantify the people movement.

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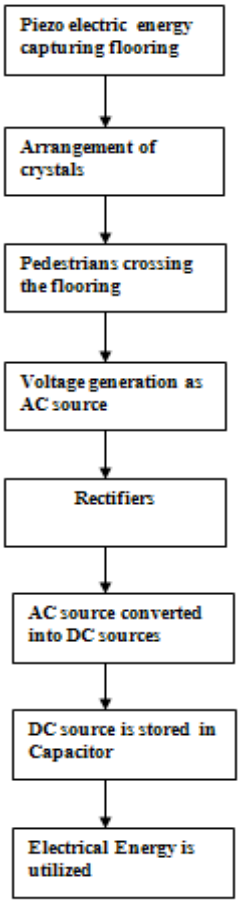

Figure 1. Showing the flow diagram of methodology Piezo electric flooring system

Certain conclusions were made from the survey and they are listed in the Table 1.The statistics are collected for the peak hours (4.30-7.30) pm and normal timing (1.30-4.30) is based on the pedestrian standing in the ticket counters.The data are collected by forming the multiplying no counters and people in the first counter similar to calculation of area of rectangle and is shown in the below table 1.

Table 1. An estimation o f the number of pedestrian crossing the railway station per day. The following is the table that gives the detailed quantification of the values taken

NAME OF THE STATION	TIMINGS	PEDESTRIANS (In Count of Number of peoples)
TAMBARAM STATION	NORMAL HOURS	470-500
TAMBARAM STATION	PEAK HOURS	700-810
EGMORE STATION	NORMAL HOURS	650-750
EGMORE STATION	PEAK HOURS	950-1260
CHENNAI BEACH STATION	NORMAL HOURS	500-600
CHENNAI BEACH STATION	PEAK HOURS	650-750
PARK STATION	NORMAL HOURS	600-700
PARK STATION	PEAK HOURS	800-900
CHENNAI CENTRAL STATION	NORMAL HOURS	1050-1200
CHENNAI CENTRAL STATION	PEAK HOURS	1250-1380

Proposed Model

The layouts of the proposed models are stated below:

1. Prototype model
2. Calculation model
3. Main model

Prototype model

The schematic representation of the proposed models are shown in the below figures and the calculation of the output is made based on the model and the data collected in the table 1.

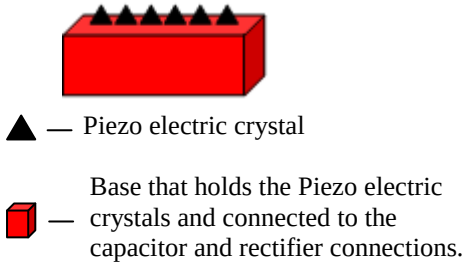

Figure 1. Shows the arrangement in the single panel of Piezo electric crystals

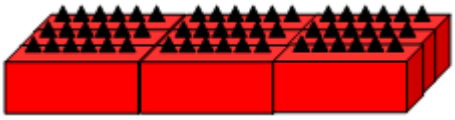

Figure 2. Shows the main prototype design of piezoelectric flooring where the single panel is combined into a set of 9 panels consisting of 54 Piezo crystals as single unit

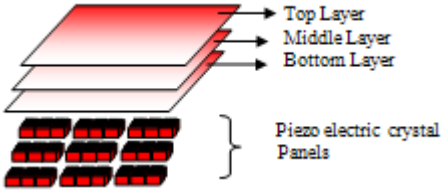

Figure 3. Shows the entire flooring layer consisting of 9 units

The following are the functions and necessary condition of the layers

1. Top layer must be comprised of tiles and to be hard and elastic for transmission of vibrations
2. Middle layer must be comprised of sponge like particle that permit only vibrations in one direction
3. Bottom must be comprised of outer coating for covering and protecting the Piezo electric crystals from damages due to heavy loading.

The model is proposed to be designed based on the following steps, firstly the idea is clearly described in the form of sketch, and then the parts required for the model is brought. When the pressure is acted upon the cover enclosing the crystals, it deforms the crystalline structure and the voltage is created due these vibrations. Later the model can be developed into greater one by conducting tests over flooring systems and increasing the efficiency by incorporating different shapes of crystals. The crystals are to be placed beneath the floor where people may walk harder, run at greater speed and luggage will be placed. After obtaining all the components, the piezoelectric crystals are to be laid beneath the 'energy-capturing' flooring where a bridge rectifier and voltage storage devices are placed. The piezocrystals are placed in several rows at series pattern. As mentioned earlier, the top layer is to be storing part (i.e. made up of hard, elastic material), the middle portion is rubber coated one where the rubber makes the pressurized impression over the crystal. And the bottom layer is arranged with piezoelectric crystals. From the various literature reviews [1] [2], it is evident that the experimental output made on the PZT gives0.3KW at

input of 0.6 KN. Thus it is making the efficiency as 50%.and in our work we calculated the efficiency of this crystals by calculating the value of output.

Table 2. Shows the different physical parameters related to different commercially available Piezo electric crystals [18].

Properties	Units	BaTiO3	PZT	PVDF
Density	103 kg/m3	5.7	7.5	1.78
Relative permittivity	ε/ε0	1,700	1,200	12
Piezoelectric strain coefficient (*d31*)	10-12 C/N	78	110	23
Piezoelectric voltage coefficient (*g31*)	10-3 Vm/N	5	10	216
Pyroelectric voltage coefficient (*Py*)	V/μm K	0.05	0.05	0.47
Electromechanical coupling constant	%@1 kHz	21	30	12
Acoustic Impedance	(10e)kg/m-sec	302.7	30	2.7

From the above table 2 it is evident that the PZT is being predominant is multipurpose usage for day to day life in implementing the energy capture flooring which reducing the need of electricity generation. From the literature and the Table 1 the follo9wing calculations are made. Considering the average weight of the person be 60 kgs and when converting the weight as mass it is to multiplied with 9.81.Thus weight of the person on the floor is 60*9.81 and the value is 600N (approximately)

The output generated for 0.6KN is 0.3KN from the reviews generating 50% efficiency And our calculation from Table1, considering the number of people Tambaram station at peak hours be 700. Thus multiplying the weight of single person with total number of persons will give the total input generated on the floor.

Total weight of the persons on the floor is 700*0.6KN generating 420KNas input and the value of output is 210KW (From Calculations).

Table 3. comparing the various aspects of energy capturing flooring with present non conventional energy sources

Source of enegy	Cost	Environmental Pollution	Effiency
Solar	High	Less	Greater
Piezo crytals	Moderate Low	Nil	50%
Wind	High	Large consumption of areas	(70%-75%)

Results and discussion

The failure of crystals is solved by adding some other compounds to like synthetic crystals. So the synthetic crystals have greater life span.

The direct impact of people's movement and load is not applied on the piezocrystals and it is ensured by the thick layering in the floor. This safety measure is done to protect the crystals from wear and tear effect.

From the calculation model the output is being generated 50% efficiency and further development on this field may increase the efficiency levels and the cost at primary level be low and mainly be developed at the small levels and futuristic it is to be developed at the large scale levels. Piezoelectric crystals which are able to resist wear and tear produce greater voltage which can be stayed for a fraction of second.

These vibrations are in the form of wave, which is of discontinuous pattern. When the voltage developed increases, the efficiency is also increased, as voltage is directly proportional to current (ohms law). The voltage developed here is in the order of thousand volts. The voltage produced is directly proportional to pressure created and the kind of piezomaterial used.

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