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Economic Viability and the Study of Energy Generation Applied through Piezeletric Materials to a Shopping System

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Abstract:

This research has as objective approach the study of the energy generation applied by means of piezoelectric materials to the local system. Due to environmental issues such as the reduction of conventional energy sources and the emission of carbon dioxide, there is a need for a clean energy system, using piezoelectric floor plates an alternative solution for capturing mechanical energy is developed and converted into electrical energy. This research presented satisfactory results, validated that the system is feasible for use in a constant transit place of people in movement. Thus, with the validated calculations and

the application of the floor in place, it is understood that the objectives of the research have economic viability, and can see future applications, being in place with a considerable daily traffic of people.

Keywords: Piezoelectric materials, Power generation, mechanical energy, electrical energy, economic viability.

Resumo:

Este trabalho tem como objetivo abordar o estudo da geração de energia aplicado por meio de materiais piezelétricos ao sistema do local. Devido às questões ambientais como a diminuição das fontes convencionais de energia e a emissão de dióxido de carbono, há necessidade de um sistema com energia limpa, utilizando placas de piso piezelétricos desenvolveu-se uma solução de alternativa para captação de energia mecânica, sendo convertida em energia elétrica. Tendo resultados satisfatórios validou-se que o sistema é viável para utilização em local de trânsito constante de pessoas em movimento. Assim, com os cálculos validados e a aplicação do piso no local, entende-se que os objetivos da pesquisa têm viabilidade econômica, podendo vislumbrar aplicações futuras em locais com um fluxo considerável de pessoas.

Palavras Chave: Materiais piezelétricos, geração de energia, energia mecânica, energia elétrica, viabilidade econômica.

INTRODUCTION:

More and more in the world we hear about studies related to energy generation and energy efficiency, as it is a technical-economic activity that aims to provide improvements, in view of the economic viability with reductions in related costs and use rational use of electricity. This project addresses the study of energy generation applied through piezoelectric materials to the site system. Such a project will be carried out as field research.

The purpose of the project is to present the amount of energy generated with the use of piezoelectric floor plates and the savings of

this energy management, through the estimated calculation of the generation of mechanical energy converted into electrical and after the projection of the implementation of this project, it will be possible to prove the advantages and the amount of energy that will be saved, thus identifying opportunities for saving energy. The referred project has its academic relevance with its study and in society with such application. It is important to emphasize that using strategies with the study of energy generation and energy efficiency, we are contributing to the improvement of the planet, applying through ecologically correct methods. Research in this area is concerned with extracting mechanical energy from the environment (pressure) and converting it to electrical with the use of piezoelectric materials. The piezoelectric effect exists in two domains: the first is the direct piezoelectric effect, in which the material has the ability to transform a mechanical stress into an electrical charge; the second way is the inverse effect, which is the ability to convert an electrical potential applied to the material into mechanical stress.

MATERIAL AND METHODS

The present work presented will be applied research, and will aim to carry out exploratory and explanatory research on bibliographic material. As for its object, bibliographic and field research obtained for the topic will be used. Technical procedures for bibliographic, documentary and experimental research will also be used depending on the expected result. The approach method used will be hypothetical-deductive and the method of elaboration procedure will be that of an article in its elaboration. For data collection, indirect documentation will be used and the analysis and interpretation of its data, qualitative, will occur globally.

Bibliographic research will be carried out in the areas of Energy Efficiency, Economic Viability, Electricity Measurement, Energy Storage, Piezoelectric Floor Types and their application. Field research will be applied to data collection, seeking to develop the best and most assertive types of tests and material monitoring. Regarding the project, it aims that these data will serve as a basis for improvements and

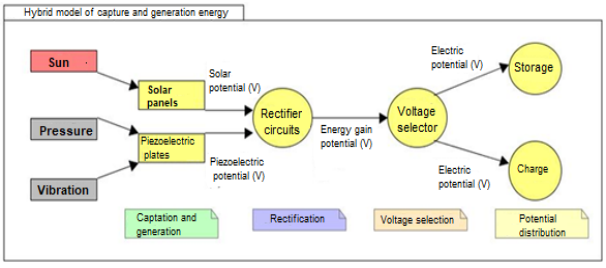
practices in energy storage related to the piezoelectric floor plate system, regarding its quality and economic investment.

The proposed technological innovation has as principle, to feed a piezoelectric platform from this kinetic loss and, consequently, generate electric energy that will be reused in the plant. Because it is a type of energy that does not need fuels or additives, piezoelectricity does not generate waste or polluting agents, unlike batteries or even oil, the burning of which generates toxic pollutants.

The use of piezoelectric materials to obtain electrical energy from the pressure exerted by human walking has been extensively studied. These studies have shown that the pressure exerted by at 68 kg person produces at 67 W of energy (STARNER, 1996). One of the first examples of this type of application incorporated a hydraulic system mounted on the sole of a shoe coupled to PZT cylindrical batteries (ANTAKI et al..1995). The hydraulic system amplifies the force on the piezoelectric stack. The initial calculations were performed in order to estimate the power generation capacity and the result was 10 W. Scale model at 1/17 was built and tested and there was a variation between at 5.7 ± 2.2 mW with a weight of 1.0 kg, in the experiment it is estimated that 6,0.

Therefore, there is a lot of equipment with substantial energy losses that can be useful if captured and, in this sense, the recovery of a fraction of this energy would have a significant economic influence and environmental impact.

Figure 1: Hybrid Capture and Generation Model



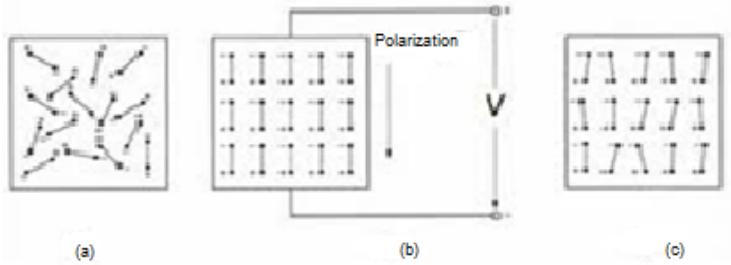
The system basically consists of 4 steps:

- **Funding and Generation**: means of energy acquisition and transduction (solar and piezoelectric plates) from external sources of electrical or mechanical excitation (sun, pressure, vibration). Rectification: The resulting electrical potentials are of a different nature (AC referring to piezoelectric plates and DC referring to solar plates). For this reason, it is necessary to adapt the type of power signal that will be distributed, depending directly on the type of load that will receive this potential.
- **Selection**: compensation is the word that represents well the meaning of this stage of the model, it concerns, to what type of energy (solar or piezoelectric) that will be applied to a consumer (load), observing the potentials generated individually and from these define the potential that will be printed.
- **Distribution**: deliver the resulting potential or ideal potential for the moment to the consumer unit or a store.

This fact directly justifies the energy gain of compensation, which in this case, in this proposed model is in charge of the potential from piezoelectric plates. It is also important to emphasize that the opposite may also occur, which depends directly on the power from the piezo ceramics, a fact that is the object of research and development for this work plan.

The piezoelectric effect exists in two domains: the first is the direct piezoelectric effect, in which the material has the ability to transform a mechanical stress into an electrical charge. The second way is the inverse effect, which is the ability to convert an electrical potential applied to the material into mechanical stress. Some manufacturers such as ELECERAM TECHNOLOGY claim that their piezoelectric actuators can achieve a maximum power of 50 W, however the mechanical pressure necessary to reach this value is not informed.

Figure 2: Floor that transforms mechanical energy into electrical energy



Analyze the number of slabs to be installed in the chosen location, to acquire an average referring to the number of people who pass the place during the day, and the number of times the floor would be stepped on, for this analysis we will have a measure of the floor plate piezoelectric, taking into account that in the "Science of the future" program, Kemball Cook states that each human step generates an average of 10J per step [Stephen Hawking, 2013]. Knowing this, you can multiply that amount of J by the total number of steps per hour, we have the amount of energy produced, so you can apply it to the energy system, obtaining savings and reusing mechanical to electrical energy;

(GOMES 2015), states that the cost of energy for industry makes families more expensive, mainly due to the fact that few people know the high share of electricity in the final cost of production.

For the implementation of this project, we have such steps and methods:

The first step to conduct the study will be data collection, referring to energy consumption at the site. It is also necessary to calculate the power used. Continuing the collection of price data in unit value of each material and piezoelectric floor plates. The second step consists of analyzing the number of people passing by the sample site and studying the average weight of the people, thus having a total value of energy accumulated on the plate, making it possible to indicate the type of material and what accumulated generated power it will supply for each area to be installed. Finally, behavior analysis will be applied through the economic viability of this operation. Subsequently, the application of this energy efficiency project will be plausible or not.

RESULTS AND DISCUSSION

The main idea was to take advantage of the energy capture property of piezoelectric materials, in order to convert the weight of the people who in the mall pass on the piezoelectric floor plates, into electrical energy. The main purpose of the scientific-technological innovation proposed in this project, from the execution of this research idea, is to carry out analysis and design of systems for capturing and generating clean and renewable energy in complexes with a large flow of people daily, based on the use of piezoelectric plates. From the use of the concept of Energy Harvesting, as well as the insertion of new technologies, comprising all scenarios where the study and application of specific methodologies take advantage of all the work done by machines, equipment, people, implying in mitigation of the cost of electricity.

According to the IBOPE website and report, 8.7 million people visit one of the Brazilian malls daily. The average number of visitors per mall is around 23 thousand people per day, but this figure varies widely depending on the size of the project and its location. According to the IBGE website, the average weight of a Brazilian is 65kg.

In financial terms, the following indicators are used: to reduce the share of energy consumption in general manufacturing expenses of strategic sectors of the enterprise. In technological terms, with the use of the hybrid capture model, compensate for the power and current losses that exist in the generation of electrical potential in piezo ceramics. In academic terms, the oriented study of the performance and efficiency evaluation of piezoelectric materials in the generation of energy.

The relevance of this project is also in using the so-called piezo ceramics, which when deformed or subjected to some mechanical stress, generates a voltage / current that can be used as a natural source of energy. Thus, the development and implementation of methods to accumulate and store the energy captured in these systems to a usable level is the key to the success of this technology.

It is worth mentioning that consumption does not have a uniform distribution, but this estimate will be used to characterize the investment. The associated cost for each kWh is approximately R $

0.3417947 per kWh. First, let's understand this unit of consumption: the kilowatt hour (kWh) is the energy spent by a device that has 1 kilowatt - or 1,000 watts - of power for one hour. Outdoor is the most powerful movement we do, a person of 68 kg generates 67 W of mechanical power when walking at 2 steps per second, reaches with a PZT transducer a range of 5,0 to 8,4 W of electrical power available in the feet (JOSÉ LUIS GONZÁLEZ, 2001).

Therefore, the maximum generation power, Pe, can be evaluated considering the losses, ζp and the damping ratio of the system, ζe, which is given by:

$$P_e = \frac{m\zeta_e A^2}{4\omega_n(\zeta_p+\zeta_e)^2}$$

Where:
A is the level of excitation acceleration;
ωn it is the natural frequency of the system;
m is the mass of the vibration system.

The installation of four signs at an entrance to a shopping center, where an average of at 23,000 people pass per day [Ibope, 2018], positioned from the main entrance to the shopping center. Considering an average of 23,000 people and that each person steps twice on each plate, 46,000 steps will be taken per day.

Figure 3: Piezoelectric floor plate

For this analysis, the Pavegen slab with dimensions of 0.60 mx 0.45 m was considered, made from 80% recyclable materials [Pavegen, 2014]. In the "Science of the Future" program, Kemball Cook states that each human step generates an average of 10 J per step [Stephen Hawking, 2013]. Multiplying this number by the total number of steps per day, the amount of "produced" energy is 460,000 J, that is, 0.1277 kWh per day.

Considering that the consumption of a 7W LED lamp used in a given space, it would consume 0.084 kWh in 12 hours. With this data, we can guarantee that the energy generated by the Piezoelectric floor could supply the demand of at least 2 LED lamps for this period of time, and can be used in a specific place. Therefore, there is savings in energy and the use of clean and renewable energy. Thus, it is perceived that the "generated" energy can supply the energy demand of a specific place of the enterprise for the same period of time, being able to use this energy in the lighting of the place.

The percentage of savings can also be increased based on the measurement that will be made of the power from the piezo ceramics, which will be evaluated and quantified during the execution of the project.

CONCLUSIONS

This article presents a possible hybrid system for generating electricity from renewable sources and energy collectors, considering the social benefits of the system's self-sustainability. Considering that the applicability is quite wide considering the industrial park in the Manaus free zone, shopping malls, colleges, football stadiums, public roads in the city with high flow of cars, it combines the proposed system with the thermoelectric and hydroelectric plants existing. With that, we can conclude that the applicability of the proposed hybrid system is recommended, despite the high cost of application and implantation.

In this work, the knowledge acquired in the Electrical Engineering course, basic knowledge of calculation and general electricity, energy efficiency and renewable energies were used. The above study proves that a long-term investment justifies the use of

alternative and sustainable sources of energy for both shopping malls and universities and for industries.

Population growth and industrialization have resulted in increased pollution and depletion of natural resources. The increase in consumption demanded the use of more natural resources, such as raw material and energy sources, which resulted in environmental degradation. One of the alternatives found to avoid environmental impacts was the use of the floor that transforms mechanical energy into electrical energy.

The floor's mode of operation is due to the piezoelectric effect, which consists of the deformation that occurs in the structure of some materials when a mechanical pressure is applied on it, causing a polarization of the loads, generating a potential difference, transforming the mechanical energy into electrical. There are several places where the floor can be used, such as: nightclubs, streets, train stations, places with a large flow of people. An analysis was carried out to determine the amount of energy generated, if signs were placed at the entrance to a shopping center. It was seen, that the energy transformed during the day would be sufficient to supply the considerable demand of a certain place.

The use of the floor still faces some difficulties and improvements are still needed, for example, one of the challenges is the storage of energy that has been carried out by super capacitors, researching cheaper forms of storage. The durability of the plate is also a problem that has been faced, since to be installed, for example, on a highway, it needs to be able to deform and return to its initial state after the stimulus has ceased, resist external agents, its constant use and not fail to produce the piezoelectric effect. Thus, we can conclude that the floor is adequate to supply small energy demands that do not require storage, and can assist in the supply of activities where consumption is momentary and discontinuous.

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