The International Journal Of Engineering And Science (IJES)
|| Volume || 5 || Issue || 12 || Pages || PP 51-54 || 2016 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

Getting of Electric Power for Pyroelectricity

Yoram Astudillo-Baza[1], Manuel Torres Sabino[2],
Manuel Alejandro López Zepeda[3]
[1,2,3]*Instituto Politécnico Nacional. ESIME Zacatenco*

ABSTRACT
This work presents a technique to produce electrical energy, this technique is called pyroelectricity. In order to produce the electric energy through pyroelectricity, it is necessary to know the electrocaloric phenomenon called pyroelectric effect, which uses as a medium that produces the electric energy to a material called ceramics PZT-4 that acts as a pyroelectric generator, used by its temperature of critical use and by its operating temperature.
Keywords: Electric Power, Pyroelectricity, Pyroelectric Effect, Ceramics PZT-4.

Date of Submission: 29 November 2016 Date of Accepted: 10 December 2016

I. INTRODUCTION

In the energy sector, new and ingenious ways of producing electrical energy appear to supply the demand of electricity that the big cities require. Even so, with the great efforts to meet the energy needs of the metropolis, it is insufficient. For this reason, man has created innovative and better ways of producing electricity; at present it has been oriented towards renewable technologies, friendly and clean for the environment.

At present, large-scale energy production depends on non-renewable sources, such as coal and fossil fuels, as developed or developing economies are heavily dependent on non-renewable raw materials, so, using electricity has drawbacks: in order to generate all that energy, the main way to produce it is by burning fossil fuels or by consuming radioactive material, mainly in thermoelectric and nuclear power plants, which generally create high levels of pollution in the environment.In recent years these plants have been modernized and evolved in combined cycle plants, this reduces pollution considerably; however, it is not enough due to the demand for energy.Nuclear power plants are at risk of malfunctioning and endangering the ecosystem and human health due to radioactivity;Nuclear power plants are at risk of malfunctioning and endangering the ecosystem and human health due to radioactivity; the most insinuated disaster is the Chernobyl catastrophe and recently the Fukushima catastrophe; these are considered the most disastrous catastrophes in history.

For this reason, this paper considers these aspects, in order to contribute to a viable and profitable solution for ecology. However, it should be mentioned that this way of obtaining energy is in the process of being studied and has focused on very small energy levels.

II. THEORY OF PYROLECTRICITY

The word pyroelectricity comes from the Greek root pyro which means fire; therefore it means electricity produced by fire. It is defined as the property of certain materials subjected to changes in temperature undergo changes in the electric polarization, so that these changes induce an electric field inside the material, caused by the movement of positive and negative charges at the opposite ends of the surface of the element.Pyroelectricity can also be defined as the ability to generate electrical charges induced on the surface of a glass when it is heated or cooled. It is explained as the transfer of positive and negative charges (and hence the establishment of an electric polarization) to the opposite ends of a crystalline polar axis, as a result of the change in temperature.

Pyroelectricity can be visualized as the side of a triangle, where each corner represents the states of energy in the crystal: kinetic, electrical, and thermal energy as shown in Fig. 1, the lines connecting the circles mean that a small Change in one of the variables produces a change.The three thick lines connecting the thermal, elastic and electrical variables define the physical properties of heat capacity, elasticity and electrical permissiveness, respectively.For example, a small increase in temperature T produces an increase in the entropy S and is proportional to the heat capacity divided by the temperature.

The figure also shows the coupled effects, indicated by the lines that join the circles in different corners of the diagram. The color lines in the diagram indicate that the two phenomena constitute the pyroelectric effect.In the first, the glass is rigidly held under constant tension S, to prevent expansion or contraction. A change in temperature causes a shift of electric displacement as shown by the green line, which means *the primary pyroelectric effect*.

The second phenomenon, *the secondary pyroelectric effect* is the result of deformation of the crystal: thermal expansion causes a tension that alters the electric displacement through a piezoelectric process, as shown by the red dotted lines.
Measuring the primary effect is extremely difficult. But the side effect can easily be calculated from the values of the coefficient of thermal expansion, the elastic stiffness and the piezoelectric tension. Thus experimentally, the pyroelectric effect is under constant stress constraint, called total effect which is the sum of red and green lines [1].
On a microscopic scale, the pyroelectric effect occurs due to the asymmetric interaction of potential, caused by electrically charged atoms, within the crystalline structure of the material.

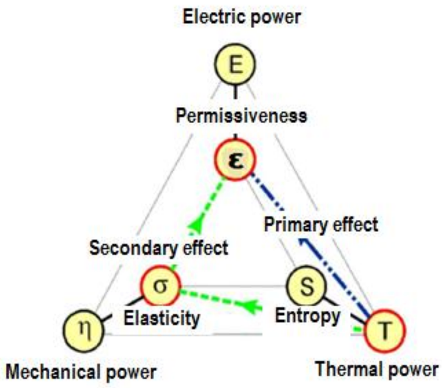

Fig. 1.A triangular diagram showingthe thermodynamically reversible interactions that can occur between the thermal, mechanical and electrical properties of a crystal [2].

Pyroelectricity is the characteristic of certain crystalline materials called pyroelectric materials (PZT-4 ceramics), when they are stimulated by temperature changes, that an electric dipole moment is generated in them and results in an electric current that is proportional to the changes in temperature.

III. SIMULATION OF THE EFFECT PYROELECTRIC (GETTING ELECTRICITY)

In this section, the demonstration of the pyroelectric effect based on computer simulation is presented using the pyroelectric material PZT-4 (lead zirconium titanate) which is a solid solution synthesized of lead titanate with lead zirconate.It is a pyroelectric ceramics most used for its critical temperature and for its operating temperature T≥200 ° C, it is capable of generating high amplitudes of vibrations keeping low the mechanical and dielectric losses.The pyroelectric effect can be obtained completely if the temperature changes in the crystal are homogeneous along the whole area of the glass; otherwise a pseudo effect occurs in the crystal. The PZT-4 material as a pyroelectric generator having a nominal operating temperature range of at least 212.5 ° K and a maximum of 1275.2 ° K.
As mentioned, obtaining electric energy using the pyroelectric effect is based on changes in temperature with respect to time. That is, the pyroelectric material will generate an alternating current that depends exclusively on the change in the state of the temperature: cold or hot. The problem is that this alternation is not always constant because the frequency at which the temperature varies is not completely stable. That is why two elementary circuits are proposed to generate, rectify and store the energy produced by the pyroelectric element. Like all sources of electric power generation, the equivalent pyroelectric circuit can be translated into an electrical scheme using passive elements, as shown in Fig. 2.

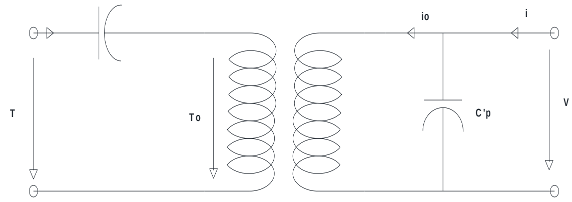

Fig. 2. Equivalent electrical diagram of a pyroelectric coupling.

In this circuit the coupling between the electrical and thermal domains is modeled as an ideal transformer. The transformation ratio F can be considered as the ratio of the electrical output to the thermal input *V/K*. In the primary circuit it is observed that the power supply is the temperature parameters T_0 and T which are frequency dependent. A resonant circuit with L and C_p that exemplifies an ideal model without losses to produce a voltage and a maximum current. In the secondary circuit appears a pyroelectric current *Io* and a voltage *V* that depend directly on the *LC* circuit, this represents the inconsistent oscillations by the variation of the elementary parameters of the pyroelectric material. The capacitor *C'p* is responsible for storing the energy produced and distributing it to a closer load.
Now, for the purposes of the simulation, the following equations will be used to obtain the results:
Pyroelectric charge:

$$\Delta Q = \Gamma A \Delta T \quad (1)$$

Element Capacitance:

$$C = \frac{\varepsilon_r \varepsilon_o A}{d} \quad (2)$$

Voltage Generated on device:

$$\Delta V = \frac{\Delta Q}{C} \quad (3)$$

Where:
ΔQIt is the total charge generated.
Γ It is the pyroelectric coefficient.
AElectrode area.
ΔTVariation of temperature.
CCapacitor.
ε_rIt is the relative permissiveness of the dielectric.
ε_o It is the permissiveness of the void.
dIt is the thickness of the pyroelectric material.
ΔVIt is the electrical voltage generated.

IV. TEST AND RESULTS

With a PZT-4 pyroelectric material with dimensions of 50 mm in diameter and 2.5 mm in thickness and a minimum rated operating temperature range of 212.55 ° K with a maximum of 1275.3 ° K and a load side resistance of 10 MΩ, Recalling that a high resistance is used to simulate an open circuit with a minimum current, tests are made and the following results are obtained (see Table 1).

Table 1. Values obtained from the simulation.

Maximum Frequency (MHz)	Maximum temperature (K)	Maximum Voltage (V)	Resistance (ohm)
0.333	212.55	0.014770	1000000
0.333	425.1	0.029541	1000000
0.333	637.65	0.044331	1000000
0.333	850.2	0.059082	1000000
0.333	1062.75	0.073852	1000000
0.333	1275.3	0.088622	1000000

The table shows the results with a frequency range of 0 to 10 MHz, a temperature of 1275.3 ° K, which is equal to 1002.1 ° C, is applied. Thus, the maximum voltage generated was 0.088622 Volts when the frequency is at 0.333 MHz. The Fig.3, shows these final results of obtaining maximum voltage of a PZT-4 material, taking the maximum values for each temperature change and the results presented in Table 1 are shown, but graphically.

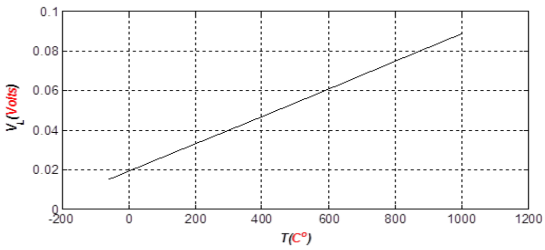

Fig. 3. Temperature vs Electric Voltage Chart.

When analyzing the data obtained from the simulation, it can be observed that in the graph of Fig. 3 and Table 1, different values of voltage are obtained which depend on the frequencies that are applied, while the temperature of 212.55 K is constant; But the maximum value is observed at 333.333 kHz due to the accuracy with which the program was made and the PZT4 data.
In the graph shows the behavior of the voltage by increasing the frequency value, you can see the decrease in voltage, which reaches its minimum value by applying a constant temperature and it was observed that it does matter that you apply a higher temperature, it generates increases in tension. It can also be observed that in the simulations similar values are obtained by taking a purely resistive load at the ends of the circuit with a value of 10 MΩ for ideal purposes simulating an open circuit with a minimum current that is negligible.
It can be concluded from the simulation presented that the temperature is directly proportional to the generated voltage. Accordingly, two equivalences were taken, in absolute temperature (Kelvin) and in ordinary temperature (Celsius degrees).

V. CONCLUSIONS

Pyroelectricity is another innovative way to obtain electric energy, as well as being environmentally friendly and being a completely profitable and renewable energy.
For the purposes of the simulation, an ideal behavior of the material was taken into consideration, in which all kinds of anomalies and constraints that a real device presents, such as elasticity, mechanical deformations and thermal dilations produced by the action of temperature are neglected. To obtain the expected results in the simulation a temperature variable with respect to time and uniformly distributed throughout the surface of the material was considered.
The results showed that at a variable temperature in a range of 212.55 to 1275.3 K maximum, since it is the nominal operating temperature of the PZT-4, with a constant frequency of 0.3333 MHz an approximate amount of tension of 0.09 V occurs in its maximum point.
For this reason, it can be concluded that this type of obtaining of electrical energy through pyroelectric materials is insufficient for the purpose of the objective of replacing the forms of energy generation, however, it was demonstrated that electric energy can be obtained and it is proposed to use the electronics to be able to raise the voltage generated and to be able to be applied.

REFERENCES

[1]. "Evolution of the Ceramic Piezoelectric Transducer". http://www. ieeeuffc. org/ ferroelectrics/ learning/articles/e003/ e0030296.pdf.
[2]. "Pyroelectricity".http://gdp.if.pwr.wroc.pl/pliki/pyroelectric-effect.pdf.
[3]. "Pyroelectric Energy Conversion: Optimization Principles".www.ieeeuffc.org/main/awards/outpapers/ t0830538.pdf.
[4]. Lang, Sidney.B "Sourcebook of pyroelectricity" 1980.
[5]. R. Potayo, M.L Calzada, L. Pardo "Pyroelectricity of spontaneously poled La-modified lead titanate thin films on silicon based substrates".
[6]. Sydney B. Lang "Pyroelectricity: From Ancient Curiosity to ModernImagingTool". http://www. slac.stanford. edu/grp/arb/tn/arbvol5/AARD459.pdf
[7]. Michel Venet Zambrano, "History of piezoelectric materials pyroelectric, electrostrictive and electro-optical effect". Process for the manufacture of piezoelectric ceramics, São Carlos, 2004.

AUTHORS

Yoram Astudillo Baza.M.Sc.in Electrical Engineering from SEPI-ESIME-IPN, Mexico in 2005. Nowadays is a Professor in mathematics from the Electrical Engineering Department in ESIME- Zacatenco. The interest areas are Analysis and Control of Electrical Power Systems, Electrical Machines, Intelligent Control, Renewable and no-Renewable energy sources.
Manuel Torres Sabino. M.Sc.in Electrical Engineering from SEPI-ESIME-IPN, Mexico in 2006.He's currently a Computer Science professor at ESIME-IPN.The interest areas are Analysis and Control of Electrical Power Systems, Electrical Machines, Microcontrollers, Renewable and no-Renewable energy sources, Power Electronics.
Manuel Alejandro López Zepeda. He received BsC and Masters in Electrical Engineering from ESIME-IPN, Mexico in 2002 and 2006. He's currently a Computer Science professor at ESIME-IPN. His research interests span state estimation in electric power systems, intelligent control and neuronal networks.Renewable and no-Renewable energy sources.