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RESEARCH ARTICLER

THE SEEBECK AND PELTIER EFFECT AND ITS IMPACT ON THE QUALITY OF THERMOELECTRIC ENERGY

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ABSTRACT

The discovery of thermoelectric phenomena two centuries ago, and the search for new alternatives for generating energy, has allowed a continuous advance in thermoelectric technology in recent years. The Seebeck effect consists of generating electrical current by subjecting the union of 2 different metals to a temperature difference; On the contrary, the Peltier effect tells us that, if an electric current is applied to the union of 2 different metals, a difference of temperatures in the joints will be appreciated. A simple principle, that the field of engineering could take advantage of to generate renewable energy, a subject of relative importance at present. With the aim of producing electricity through the aforementioned phenomena, a thermoelectric generator based on peltier cells was built, capable of providing 5 volts; enough to charge a cell phone. The generator consisted of two Peltier cells, each capable of generating 3 volts with a temperature differential of 70 º C between their faces; However, during the experiment, only 2.7 volts of energy were recorded, demonstrating that only 90% of the thermal energy provided is transformed into electricity. It was also determined that the voltage decreased by 10% every 3 minutes, so the temperature differential had to be kept increasing and thus breaking the "seebeck constant". The methodology that informed the development of the project was the analysis and synthesis of primary sources such as books and reports, and secondary sources such as documents or web pages. At the end of the investigation and construction of the model, it was concluded that Peltier cells work based on the temperature differential, which could be exploited with innovative methods of renewable energy production such as the water-steam cycle or the combustion of biomass.

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INTRODUCTION

The Peltier effect is characterized by the appearance of a temperature difference between the two faces of a semiconductor when a current flows through it. A Peltier cell is made up of two semiconductor materials, one of type P and another of type N in an arrangement like the one shown in Figure 1, producing the so-called Peltier thermoelectric effect internally (M. Krutz, 1975 and Rowe, 2006). Internally the Peltier cell has highly contaminated semiconductor elements and electrically arranged in series by copper conductors (M. Krutz, 1975 and Rowe, 2006). To isolate the copper conductors the trigger is added between them a ceramic plate that works as an insulator (Figure 2). A polarization as shown in Figure 3, is distributed along each semiconductor element of the yield, in each semiconductor element has a "potential difference"." (Fermi, 1985), proportional to the input polarization. For this reason, the majority carriers, weakly bound electrons, migrate towards the positive side of each of their ends in the N-type semiconductor elements, due to the attraction of charges of different sign. While the majority carriers, holes of the semiconductor elements P, migrate towards the negative terminal that is at each of its ends, this absence of charges in each semiconductor element near the metal-semiconductor junction causes a rarefying of charges and the consequent drop in temperature in the surrounding area (Rowe, 2006 and Burke). On the other hand, the compression and accumulation of carriers near the semiconductor metal junction in the lower part of the semiconductor elements in Figure 3 causes a rise in temperature. This behavior indicates that, if the polarity of the power supply is reversed, the cold face will now warm up and the hot face will suffer a drop in temperature (Besançon, Robert, 1985). Motivated by the practical interest in the generation of energy in an alternative way, this work deals with the theme of the characterization of a Peltier cell[4] *(E.J: Brukle)*. This document is organized as follows: the Methodology section describes what the characterization tests consist of; in the Results and Discussion section describes the built platform, as well as the results obtained; In the following section some conclusions are given

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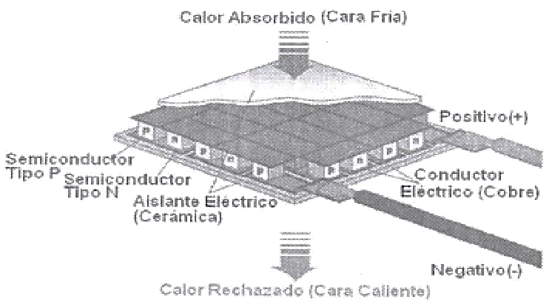
and finally, in the last section some references used in the elaboration of the project are provided.

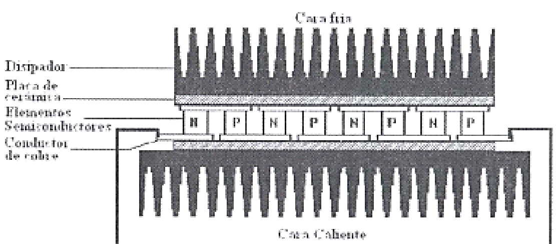
MATERIALS AND METHODS

The "thermoelectric effect" (Rowe, 2006) *(Fermi.E)* is the direct conversion of the temperature difference to electrical voltage and vice versa. A thermoelectric device creates a voltage when there is a temperature difference on each side. On the contrary, when a voltage is applied, it creates a temperature difference (known as the Peltier effect). At an atomic scale (especially load carriers), an applied temperature gradient causes charged carriers in the material, if there are electrons or gaps, to diffuse from the hot side to the cold side, similar to a classical gas that expands when it is heats up; consequently, the current is thermally induced. This effect can be used to generate electricity, measure temperature, cool objects, or heat or cook them. Because the direction of heating or cooling is determined by the sign of the applied voltage, thermoelectric devices produce very convenient temperature controllers. Traditionally, the term thermoelectric effect or thermoelectricity encompasses three separately identified effects, the Seebeck effect, the Peltier effect, and the Thomson effect. In many textbooks, the thermoelectric effect can be called the Peltier-Seebeck effect. This separation comes from independent discoveries of the French physicist Jean Peltier and the Estonian-German physicist Thomas Johann Seebeck. The Joule effect, the heat generated when a voltage is applied through a resistive material, is a related phenomenon, although it is not generally termed a thermoelectric effect (and is usually considered as a loss mechanism due to the non-ideality of thermoelectric devices). The Peltier-Seebeck and Thomson effects can in principle be thermodynamically reversible, whereas Joule heating is not.



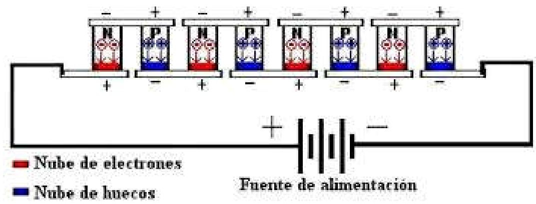
Source: M. Krutz, *Temperature Control. Huntintong*

Figure 1. Diagram showing the internal structure of a Peltier cell, where the semiconductor elements arranged electrically in series and thermally in parallel are observed



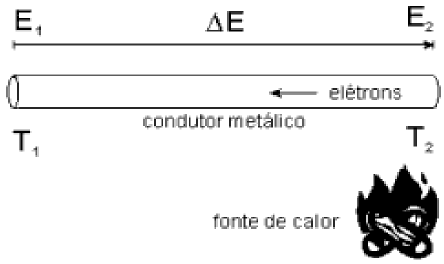
Source: *Besançon, Robert M.* (1985)

Figure 2. Cross section of the Peltier cell, showing semiconductor elements and dissipating fins



Source: Rowe, D. M. (2006). *Thermoelectrics Handbook:Macro to Nano*

Figure 3. Compression and rarefaction of charge carriers near the semiconductor metal junction in a Peltier cell



Source: Fermi E., Termodinámica, EUDEBA, 1985

Figure 4. Thermoelectric principle

It consists in the heating or cooling of a union between two different metals (isothermal interface) when passing current through it. By inverting the current, the direction of the heat flow is also inverted. This effect is reversible and independent of the dimensions of the driver. It depends only on the type of metal and the temperature of the joint. This work is related to the characterization of a Peltier cell. Said characterization consists of describing the behavior of the cell current against the temperature difference (ΔT) for 6 different polarization voltage levels. The cell is fed with a direct current voltage through its terminals. The characterization procedure consists of making a record of the behavior of the temperature difference between the faces of the cell against time. Additionally, it is necessary to record the polarization current and voltage. The operating time of the cell for each measurement event, at a different voltage level, is 45 minutes, allowing a lapse of at least 2 hours between event and event.
Once the correct functioning of the Peltier cells has been checked and its behavior has been analyzed for the different levels of polarization voltage. A cellular charger was built, consisting of two Peltier cells and a voltage booster module.

Hypothesis

Hi: Pertier cells are capable of generating quality thermoelectric energy through a thermal coke. (hot Cold)
Ho: Pertier cells are not capable of generating quality thermoelectric energy through a thermal coke. (hot Cold)

RESULTS

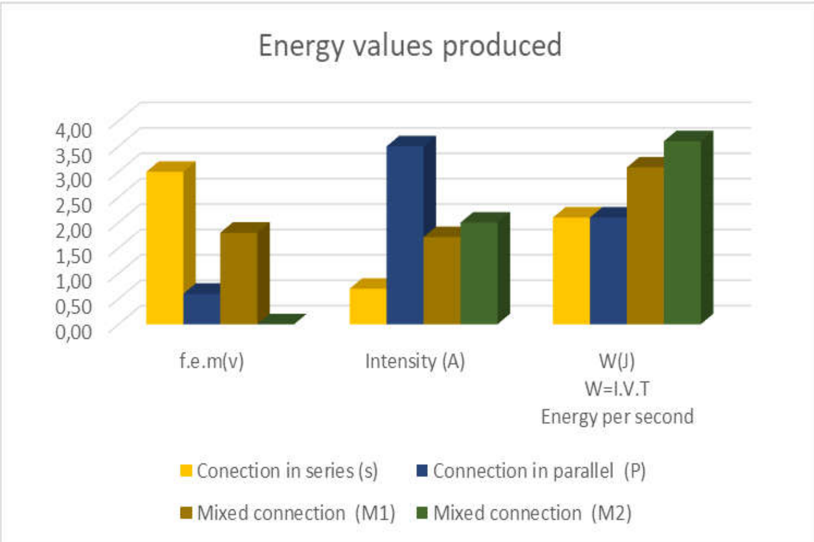
For the study of the polarization in the cells, the acquired parameters were: module voltage, module current, cold face temperature, hot face temperature and time. The maximum polarization voltage of the Peltier module used is 6 VDC, with a nominal current of 3 A and a temperature difference of 40 º C. The different characterization tests were carried out according to the methodology described above in the corresponding section. The polarization voltage level was increasing from 1 V to 6 V in 1V increments. the results obtained for the behavior of the temperatures of the cold and hot faces as a function of time are shown in Figure 7.

Table 1.1 Electromotive force and intensity values

1. item	2. f.e.m(v)	3. Intensity (A)	4. W(J) 5. W=I.V.T Energy per second
Conection in series 1. (s)	2. 3. 3,000 4.	5. 6. 0,700	7. 8. 2,100
Connection in parallel 1. (P)	2. 3. 0,600 4.	5. 6. 3,500	7. 8. 2,100
Mixed connection 1. (M1)	2. 3. 1,800	4. 5. 1,714	6. 7. 3,086
Mixed connection 1. (M2)	2. 3. 1,800	4. 5. 2,000	6. 7. 3,600

Source: Author

Graph 1.1. Energy Values produced



Source: Author

Graph 1.1. Energy Values produced

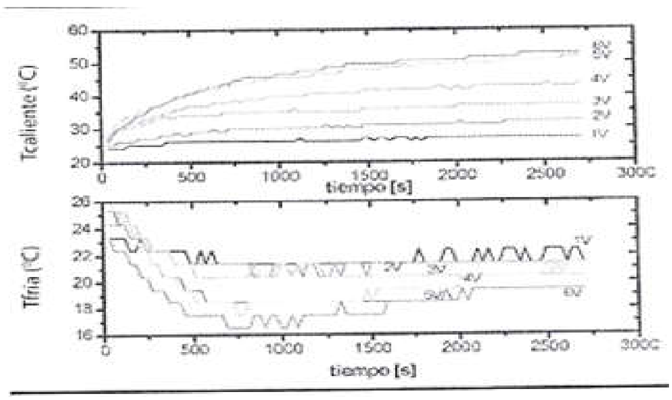


Figure 5. Temperature behavior on both the cold and hot face of the Pertier cell with respect to time

It can be seen from said figure that as time passes a higher temperature is reached in the hot face and consequently a temperature lower on the cold side for a higher polarization voltage. Similarly, it can be seen that, in the case of a polarization voltage of 6V, once the process is started, the minimum temperature on the cold side is 16 ° C and after the first 12 minutes, there is a gradual increase in temperature. the temperature of 3 ºC in 27 minutes. This means that a minimum differential of 26ºC in two peltier cells can generate approximately 6 V and 2 A of energy, enough to be able to charge a cell phone that was the initial objective of the project. The data obtained by each Peltier cell are detailed in Table 1.1.

With this data in mind, the construction of the circuit responsible for transmitting the current obtained from the Peltier cells was carried out. The previous table shows the data based on the temperature differentials that were previously exposed, whose data are recorded in Figure 5.

Fuente: D.M. Rowe, *Thermoelectrics Handbook*: macro to nano. Boca Ratón, Florida: CRC PRess, 2006. Pp. 1-1-1-1-7. Finally, a cellular charger was obtained, essentially composed of two Peltier cells, a voltage booster module and a cellular connection cable.

DISCUSSION

As we can see, this mechanism of heat transfer and thermal coke that leads to join a source of cooling with a heat generator produces pure electricity that would have a number of uses. We can observe for example when a car travels a certain distance and its engine generates heat, and the radiator that is usually the cold source that could be absorbed this heat transfer by the thermoelectric cells generating a n amount of energy that served for the auto sustentation of the same automotive. A basis for this has been done in hybrid cars, but the issue must still be developed because of the differential that Pertier's cell requires to generate this energy.

Conclusions

- It was shown that electric power can be generated through the peltier effect developed by a systematic model.
- With the knowledge acquired from the operation of the PELTIER system it is possible to obtain sources of clean energy to be able to generate this type of thermoelectric power and thus obtain permanent regeneration.
- It is determined that the peltier plates need a high thermal difference from which that thermal variation will depend much on the quality of energy obtained.
- The radiator is an important source for the cooling of the elaborate systemic model that can be used for the manufacture of hybrid car cells in the future.
- Finally, the expected results were obtained based on the document planned in the experimentation of the use of the Pertier cells.

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