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A Review on Applications of Peltier Devices

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Abstract: This paper presents a study on the recovery of waste thermal energy using thermoelectric modules for application in vehicles that could benefit from the generation of a small amount of electric current. A large amount of energy is wasted within the engine and in car cooling, energy that could otherwise be recovered by thermoelectric effect. Thermoelectric device is a solid-state active heat pump which transfers heat from one side of the device to the other side against the temperature gradient (from cold to hot), with consumption of electrical energy, also known as Peltier device. The conclusion appears really attractive economically and energy cogeneration using thermoelectric modules is totally clean.

Keywords*-- *Thermoelectric, Peltier Effect, temperature gradient, Applications.

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1. INTRODUCTION

The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice-versa. A thermoelectric device cause a voltage when there is a different temperature on each side. Contrarily, when a voltage is applied to it, it creates a temperature difference. An applied temperature gradient causes charge carriers in the material to diffuse from the hot side to the cold side, identical to a gas that expands when heated; hence inducing a thermal current. This outcome can be used to produce electricity, measure temperature or change the temperature of objects. Considering the direction of heating and cooling is determined by the polarity of the applied voltage, thermoelectric instrument is efficient temperature controllers. Thermoelectric devices utilize the Seebeck effect, Peltier effect and Thomson effect. The Peltier–Seebeck and Thomson effects are thermodynamically reversible whereas Joule heating is not.

2. PELTIER EFFECT

The term "thermoelectric effect" encompasses three separately identified effects: the Seebeck effect, Peltier effect, and Thomson effect. The Peltier effect is the presence of heating or cooling at an electrified junction of two different conductors and is named after French physicist Jean Charles Athanase Peltier, who discovered it in 1834.

When a current is made to flow through a junction between two conductors A and B, heat may be generated (or removed) at the junction. The Peltier heat generated at the junction per unit time, $\dot{Q}$, is equal to

$$\dot{Q} = (\Pi_A - \Pi_B) I$$

Where Π_A (Π_B) is the Peltier coefficient of conductor A (B), and I is the electric current (from A to B). Note that the total heat generated at the junction is not determined by the Peltier effect alone, as it may also be influenced by Joule heating and thermal gradient effects.

The Peltier coefficients represent how much heat is carried per unit charge. Since charge current must be continuous across a junction, the associated heat flow will develop a discontinuity if Π_A and Π_B are different.

A typical Peltier heat pump device involves multiple junctions in series, through which a current is driven. Some of the junctions lose heat due to the Peltier effect, while others gainheat. Thermoelectric heat pumps exploit this phenomenon, as do thermoelectric cooling devices found in refrigerators.

3. CONSTRUCTION

The smallest component of a thermal element is the thermocouple. It consists of two electrical conductors with very different Seebeck coefficients to generate the highest possible thermoelectric voltage. The material used ismost often semiconductor blocks connected at the ends with a copper at Peltier element consists of a multitude of thermocouples connected electrically in seriesby copper bridges. These bridges on each side are thermally bonded together by ceramic plates (usually aluminum oxide), ad are electrically isolated. Even if p- and n-doped materialis being used, it should have direct contact to inhibit the current flow in one direction.But in petlier this is not helpful and the various semiconductors are connected by metal bridges. Semiconductors are preferred over other conductor materials because materials with high thermoelectric voltage have been found in this material group that conduct electricity very good, but they are thermally isolating. Only then can the cold side be effectively separated from the warm and produce a usable temperature difference on ground, or at sea.

4. N-TYPE AND P-TYPE DEVICES

A Peltier element may be used to produce electrical power or to pump heat (via the Peltier effect). In general,the power provided by a single Peltier element is generally not sufficient for realistic situations. To increase their output,commercial Peltier devices consist of many n-type and p-type semiconductor Peltier elements. The 5 individual elements are connected in series using metal junctions. As a result of this, the junctions between the semiconductors do not form a barrier

Potential, as they would do in a p-n diode, and charge carriers are able to flow freely in both directions. In a Peltier device, the individual elements are arranged in such a manner that the heat from n- and p-type flow in the same direction A complete Peltier device architecture is shown. It consists of two insulating ceramic plates p-n pairs joined by copper in between them.

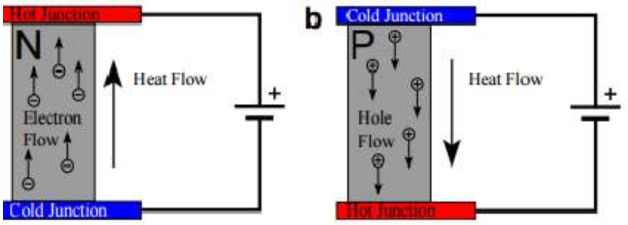

Figure 4.1: n-type versus p-type Peltier elements

5. COMMERCIAL DEVICES

A single Peltier maybe used to produce electrical power (via the Seebeck effect) or to pump heat (via the Peltier effect). In either application, the power provided by a Peltier element is generally not sufficient for realistic situations. To increase the output, commercial devices are composed of many n-type and p-type semiconductor Peltier elements. The individual elements are connected in series using metal. As as result of this, the junctions between the semiconductors do not form a barrierpotential, as they would do in a p-n diode, and charge carriers are able to flow freely in both directions. Here, the individual elements are arranged in such a mannerthat the heat from n- and p-type flow in the same direction A complete Peltier device architecture is shown. It consists of electrically insulating ceramic plates that sandwich a series of p-n pairs joined by copper. This design provides a large surface area improving heat pumping for cooling and heating applications**.**

6. CONCLUSION

1. Thermoelectric technology has been used practically in wide areas in recent times. The thermoelectric devices can act as power generators, thermal energy sensors or coolers and are used in almost all the fields such as military, instrument, medicine, biology and industrial or commercial products.

2. Still thermoelectricity not used more widely because the coupling between the electrical and heat currents is weak in most materials, and the overall energy conversion productivity is therefore very low. Hence, researchers are working hard to discover new p- and n-type semiconductors, which can do this more effortlessly.

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