APPLICATION OF TEC MODULE IN COOLING AND REFRIGERATION

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Abstract: The process of keeping an item below room temperature by storing the item in a system or substance designed to cool or freeze is known as refrigeration. The most common form of refrigeration is provided by systems (i.e. refrigerators) that use a refrigerant chemical to remove heat from items stored inside the system. All the refrigeration methods are based on Reverse Carnot cycle, with Adiabatic and Isothermal Expansion and Compression but now a day, thermoelectricity phenomenon has used in various sector. It works on the concept of thermocouple, which obtains a potential difference by maintaining two junction at different temperature and vice versa. This phenomenon of getting potential difference or getting temperature difference is used in refrigeration and air conditioning respectively which helps to minimize the pollution from conventional system. It directly convert temperature difference into voltage.

Keywords: Peltier Effect, Thermoelectric module, Refrigeration.

I. INTRODUCTION

Refrigeration is a process in which the temperature is maintained below the room temperature for this thermoelectric phenomenon is used, it deals with the conversion of thermal energy into electrical energy and vice-versa. A thermoelectric device creates voltage when there is a different temperature on each side. When a voltage is applied to it, it creates a temperature difference. When operating in a cooling or heating mode the thermoelectric device is termed as a thermoelectric cooler (TEC). Similarly, the thermoelectric device produces heating or cooling that takes the form a heat flux which then induces a temperature difference across the TEC. Thermoelectric devices are solid-state mechanisms that are capable of producing these three effects without any intermediary fluids or processes. This allows quiet cooling operations compared to conventional compressor-based refrigeration systems and produce no pollutants or environmentally detrimental by-products. There is no moving part used and therefore reducing the susceptibility of damage. These criteria make thermoelectric devices highly attractive for a multitude of applications. On the other hand, thermoelectric devices are widely implemented for heating, ventilation and air-conditioning (HVAC) purposes in vehicles. These take the form of thermoelectric air-conditioners and climate controlled seats that may potentially replace conventional compressor-based air-conditioning systems in automobiles [2]. These TECs can also be embedded into microprocessors to achieve precise temperature control as well as hot spot mitigation when physical space around the microprocessor is limited [3].

II. THERMOELECTRIC PHENOMENON

The term “thermoelectric effect” encompasses three separately identified effects, the Seebeck effect, Peltier effect, and Thomson effect. Most widely it is known as Peltier-Seebeck effect. The discovery of the thermoelectricity began in 1821 when a German physicist, by the name of Thomas Johann Seebeck, discovered that an electromotive potential (or electrical voltage) was produced in a circuit of two dissimilar metals when one of the junctions of circuit was heated or at a higher temperature than the other junction (refer to Figure 1) [4]. The proportionality of the electrical potential to temperature difference was governed by the Seebeck coefficient, which is an inherent property of the circuit of two dissimilar metals. The relationship between voltage and temperature difference is(1.1) where is the voltage across the junctions of the circuit, is the Seebeck coefficient and is the temperature difference across the junctions of the circuit. The Seebeck effect is the conversion of heat directly into electricity at the junction of different types of wire. In figure.1 we could see that there is a hot junction and a cold junction and the direction of current is generated due to potential difference.

Fig: 1.Seeback effect

III. HOW IT WORKS
When two conductors are placed in electric contact, electrons flow out of the one in which the electrons are less bound, into the one where the electrons are more bound. The reason for this is a difference in the Fermi level between the two conductors. The Fermi level represents the dividing line in energy within the conduction band of a metal, between the energy levels occupied by electrons and those that are unoccupied.

When two conductors with different Fermi levels make contact, electrons flow from the conductor with the higher level, until the change in electrostatic potential brings the two Fermi levels to the same value. Current passing across the junction results in either a forward or reverse bias, resulting in a temperature gradient. If the temperature of the hotter junction (heat sink) is kept low by removing the generated heat, the temperature of the cold plate can be cooled by tens of degrees (Fig 2).

IV. FEATURES OF THERMOELECTRIC MODULE

Some of the significant features of the thermoelectric modules are given below:

1. No moving parts: - A thermoelectric module works electrically without any moving parts so they are virtually maintenance free and the damage could also be less.

2. Small size and weight: - The overall thermoelectric cooling system is much smaller and lighter than a comparable mechanical system. In addition, a variety of standard and special sizes and configurations are available to meet strict application requirements therefore it is less complicated.

3. Ability to cool below ambient: - Unlike a conventional heat sink whose temperature necessarily must rise above ambient, a thermoelectric system attached to that same heat sink has the ability to reduce the temperature below the ambient value.

4. Precise temperature control: - With an appropriate closed-loop temperature control circuit, thermoelectric module can control temperatures to better than +/-0.1°C.

5. High Reliability: - Thermoelectric modules exhibit very high reliability due to their solid state construction. Although reliability is somewhat application dependent, the life of typical thermoelectric system is greater than 200,000 hours.

6. Electrically Quite Operation: - unlike a mechanical refrigeration system, thermoelectric modules generate virtually no electric noise and can be used in conjunction with sensitive electronic sensors. They are also acoustically silent.

7. Operation in any Orientation: - Thermoelectric modules can be used in any orientation and in zero gravity environments. Thus they are popular in many aerospace applications.

8. Convenient Power Supply: - Thermoelectric modules operate directly from a DC power source.

9. Spot Cooling: - With a thermoelectric module it is possible to cool one specific component or area only, thereby often making it necessary to cool an entire package or enclosure.

10. Ability to Generate Electric Power: - When used „in reverse“ by applying a temperature differential across the faces of a thermoelectric refrigeration system, it is responsible to generate a small amount of DC power.

11. Environmental Friendly: - Conventional refrigeration system cannot be fabricated without using chlorofluorocarbons or other chemicals that may be harmful to environment. Thermoelectric devices do not use or generate gases of any kind.

V. APPLICATIONS

A. Application of thermoelectric devices as cooler-

Thermoelectric cooling is a form of solid-state refrigeration; it has the advantage of being compact and
durable. A thermoelectric cooler uses no moving parts (except for some fans), and employs no fluids, eliminating the need for bulky piping and mechanical compressors used in vapour-cycle cooling systems. Such sturdiness allows thermoelectric cooling to be used where conventional refrigeration would fail. Thermoelectric devices also have the advantage of being able to maintain a much narrower temperature range than conventional refrigeration. They can maintain a target temperature to within ±1° or better, while conventional refrigeration varies over several degrees. Unfortunately, modules tend to be expensive, limiting their use in applications that call for more than 1 kwh of cooling power. Owing to their small size, if nothing else, there are also limits to the maximum temperature differential that can be achieved between one side of a thermoelectric module and the other. However, in applications requiring a higher T, modules can be cascaded by stacking one module on top of another. When one module’s cold side is another’s hot side, some unusually cold temperatures can be achieved [1].

B. Solar Water Condensation Using Thermoelectric Coolers

A solar water condensation system is built using a TE cooler, solar panels, heat exchange unit and an electronic control unit. The system is self powered and can be used in isolated and desert areas to condensate water from the surrounding humid air. Applying the system in high humidity see area produced 1L of water per hour which can be used mainly for irrigation. The economical advantage of this kind of system is still obscure due to the relatively high installation cost. This system would be a long-term cost saving system since the energy source is free and the solar sub-system generally requires little maintenance. The development and production of such equipment is a future business possibility.

C. For medical application

Thermoelectric cooling is widely used in many areas of science and technology, in particular, in medicine. It is well known in medical practice that temperature effects are an important factor in treatment of many diseases of the human organism. To achieve low temperatures, systems with liquid nitrogen are used, which limits their use in hospitals significantly. In most cases such devices are bulky, without proper temperature control and thermal modes reproduction. Therefore, the use of thermal effects on the patient is confronted with some difficulties and is reduced mainly to the application of ice or hot water. The use of thermoelectric cooling can solve this problem, because it has several advantages, if compared to conventional techniques of thermal effects. Fundamental research on the application of thermoelectric cooling in medicine confirms the possibility of its practical application in such areas of medicine as cryotherapy, cryosurgery, ophthalmology, and traumatology.

VI. CONCLUSIONS

This paper describes use of Thermoelectric cooling technology in different sector, which are as follows.

1. Thermoelectric technology has been used practically in wide areas recently like in refrigerators and cooling appliances and are used in almost all the fields such as military, aerospace, instrument, biology, medicine 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 efficiency is therefore very low. Therefore, researchers are working hard to discover new p- and n-type semiconductors, which can do this more efficiently.

REFERENCES


