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DEVELOPMENTS OF THERMOELECTRIC REFRIGERATION SYSTEMS BY USING PELTIER EFFECT

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ABSTRACT :

Refrigeration has made the milestone in human life. Since from very long time the human being has developed so many ways of refrigeration for preserving food, cooling water, etc. but yet the techniques are developing. The science of refrigeration has developed so many ways to improve our lifestyle.

The research focused on simulation of a thermoelectric refrigerator maintained at 4oC. The performance of the refrigerator was simulated using Matlab under varying operating conditions. The system consisted of the refrigeration chamber, thermoelectric modules, heat source and heat sink. Results show that the coefficient of performance (C.O.P) which is a criterion of performance of such device is a function of the temperature between the source and sink. For maximum efficiency the temperature difference is to be kept to the barest minimum.

Thermoelectric cooling uses the Peltier effect to create a heat flux between the junctions of two different types of materials. A Peltier cooler, heater, or thermoelectric heat pump is a solid-state active heat pump which transfers heat from one side of the device to the other, with consumption of electrical energy, depending on the direction of the current. Such an instrument is also called a Peltier device, Peltier heat pump, solid state refrigerator, or thermoelectric cooler (TEC). It can be used either for heating or for cooling, although in practice the main application is cooling. It can also be used as a temperature controller that either heats or cools.

INTRODUCTION:

Refrigeration term is known from the 18 century after there are four well known cooling systems, Vapour Compression, absorption, thermoelectric and newly known Thermo-acoustic refrigeration system. The cooling effect produced by refrigeration system is based on simple principle of operation, that a heat flux is absorbed from a room, and evacuated to exterior. In domestic refrigerators, the most used cooling system is vapour compression, as it has a good value of coefficient of performance (COP). Thermoelectric refrigerators (TER) offer several advantages over vapour-compression

Refrigerators such as free of moving parts, acoustically silent, reliable, and lightweight. But because of their low efficiency and peak heat flux capabilities have precluded their use in more widespread applications. Peltier effect and Seebeck effect were first discovered to present in metals as early as1820s–1830s, but the low thermoelectric performances of metal made these two effects fall on deaf ears all the time. Until 1950s, the advent of doped semiconductor materials with small band gap, large Seebeck coefficients, good electrical conductivities, and poor thermal conductivities were found to have much bigger thermoelectric performances than the pure metals, thus revived the interest in this field.

LITERATURE REVIEW

Dai et al. [5] have designed and developed a thermoelectric refrigeration system powered by solar cells generated DC voltage and carried out experimental investigation and analysis. They developed a prototype which consists of a thermoelectric module, array of solar cell, controller, storage battery and rectifier. The system with solar cells and thermoelectric refrigerator is used for outside purpose in daytime and system with storage battery, AC rectifier and TER is used in night time when AC power is available. Experimental analysis on the unit was conducted mainly under sunshine conditions. The studied refrigerator can maintain the temperature in refrigerated space at 5–10oC, and has a COP about 0.3 under given conditions.

Min et al. [6] developed a number of prototype thermoelectric domestic-refrigerators with different heat exchanger combination and evaluated their cooling performances in terms of the COP, heat pumping capacity, cooling down rate and temperature stability. The COP of a thermoelectric refrigerator is found to be 0.3-0.5 for a typical operating temperature of 5oC with ambient at 25oC. The potential improvement in the cooling performance of a thermoelectric refrigerator is also investigated employing a realistic model, with experimental data obtained from this work. The results show that an increase in its COP is possible through improvements in module contact resistances, thermal interfaces and the effectiveness of heat exchangers.

Wahab et al. [7] designed and developed an affordable thermoelectric refrigerator powered by solar cells generated DC voltage for the desert people living in Oman where electricity is not available. In this study the researchers used 10 nos. of thermoelectric module in design of refrigerator

2.1 Basic principle of thermoelectric materials

The introduction of thermoelectric cooling, as renewed technology, has made an impact in the field of alternative refrigeration. The common principle is the presence of coupled electrical and thermal currents, so that it is possible to use the effects to generate power from a temperature differential.

The basic principle behind thermoelectric effect is *Peltier effect*- it occurs whenever electric current flows between two dissimilar conductors, depending on the direction of the current flow, the junction of the two conductors will either absorb or release heat.

A thermoelectric material is made of two legs, one of which is ‘n-type’ and contains negatively charged mobile carriers in the form of electrons while the other leg is ‘p-type’ and contains positively charged mobile carriers known as holes. These two legs are connected electrically in series and thermally in parallel.

THERMOELECRIC MATERIAL

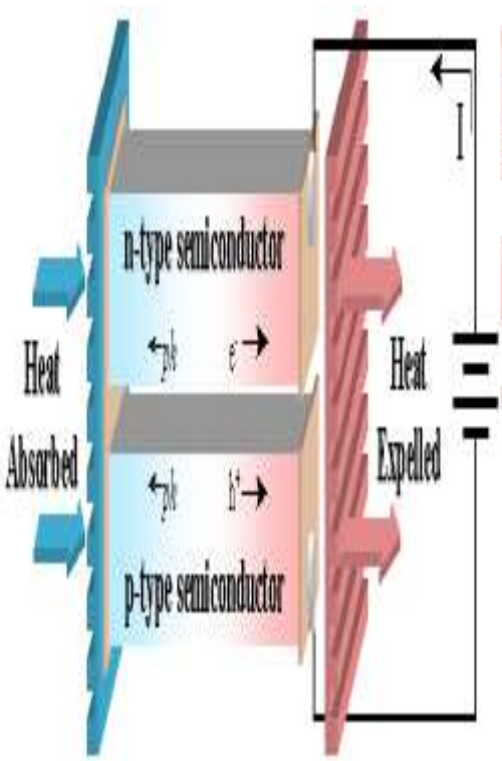
The common Thermoelctric Material used in Different applications are Bismuth sulfide(Bi_2S_3), Lead Telluride(PbTe), Antimony Telluride(Sb_2Te_3), Cesium Sulfide(CeS), Bismuth telluride(Bi_2Te_3), and Germanium

Assumptions

No heat loss takes place from or to the system.

Thermo physical properties such as Resistivity, conductivity etc do not change with temperature.

Heat transfer takes place only through the P type and N type semiconductor.



METHODOLOGY

1 . Seebeck effect

Consider the junction of two materials, A and B. If a temperature differential exists between the two junctions, one junction may be referred to as the hot side and the other the cold side. An open circuit voltage can be measured between the two junctions. This net conversion of thermal energy into electrical energy under zero current conditions is known as the Seebeck effect. The voltage observed, referred to as the Seebeck voltage, is proportional to the temperature differential between the hot and cold sides of the couple.

2. Peltier Effect

The Peltier effect is localized at the junctions between materials A and B. When a current flows through the junction, heat is either liberated or absorbed depending on the direction of the current flow. The amount of heat is proportional to the current and is known as the Peltier heat

3. Thomson Effect

This effect concerns the absorption or generation of heat in a conductor carrying a current in the presence of a temperature gradient. The amount of heat is proportional to the current and temperature g Refrigeration.

Working diagram

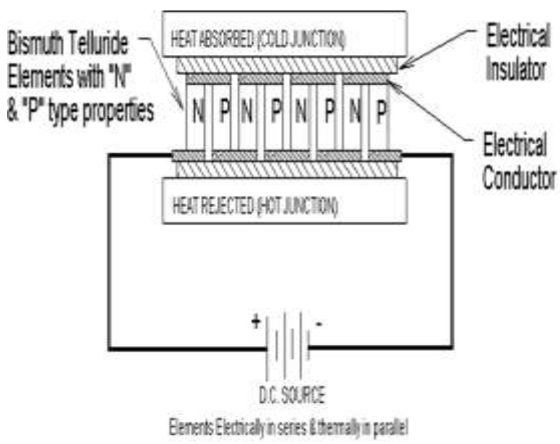


Figure : Thermoelectric module Assembly

WORKING :

In 1834 Jean Peltier noted that when an electrical current is applied across the junction of two dissimilar metals, heat is removed from one of the metals and transferred to the other. This is the basis of thermoelectric refrigeration. Thermoelectric modules are constructed from a series of tiny metal cubes of dissimilar exotic metals which are physically bonded together and connected electrically. When electrical current passes through the cube junctions, heat is transferred from one metal to the other. Solid-state thermoelectric modules are capable of transferring large quantities of heat when connected to a heat absorbing device on one side and a heat dissipating device on the other.

The internal aluminium cold plate fins absorb heat from the contents, (food and beverages), and the thermoelectric modules transfer it to heat dissipating fins under the control panel. Here, a small fan helps to disperse the heat into the air. The system is totally environmentally friendly and contains no hazardous gases, nor pipes nor coils and no compressor.

The only moving part is the small 12-volt fan. Thermoelectric modules are too expensive for normal domestic and commercial applications which run only on regular household current. They are ideally suited to recreational applications because they are lightweight, compact, insensitive to motion or tilting, have no moving parts, and can operate directly from 12-volt batteries.

Calculation

Units of Refrigeration

Domestic and commercial refrigerators may be rated in kj/s, or Btu/h of cooling. Commercial refrigerators in the US are in tons of refrigeration, but elsewhere in kw. One ton of refrigeration capacity can freeze one short ton of water at 0 ºC (32 ºF) in 24 hours.

Latent heat of ice (i.e. heat of fusion) = 333.55 kj/kg ≈ 144 Btu/lb

The practical unit of refrigeration is expressed in terms of „tonne of refrigeration" (briefly written as TR). A tonne of refrigeration is defined as the amount of refrigeration effect produced by the uniform melting of one tonne (1000 kg) of ice from and 0 ºC in 24 hours. Since the latent heat of ice is 335 kj/kg, therefore one tonne of refrigeration,

1 TR = 1000 335 kJ in 24 Hours = 232.6 kJ/min

In actual practice, one tonne of refrigeration is taken as equivalent to 210 kj/min or 3.5 kW (i.e. 3.5k/s).

CONCLUSIONS :

The literature regarding the investigation of Thermoelectric air conditioner using different modules has been thoroughly reviewed .From the review of the pertinent literature presented above, it can be inferred that thermoelectric technology using different modules used for cooling as well as heating application has considerable attention. Many researchers try to improve the COP of the thermoelectric air-conditioner using different material. Thermoelectric coolers to be practical and competitive with more traditional forms of technology, the thermoelectric devices must reach a comparable level of efficiency at converting between thermal and electric energy.

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