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Solar Power Based Thermoelctric Cooling

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ABSTRACT

Thermoelectric cooler is also called thermoelectric module or Peltrier coolers. They are semiconductor based electronic components that function as small heat pumps. On applying a low DC voltage to the thermoelectric module, heat moves through the module from one side to the other. One face of module is therefore cooled, while the other face simultaneously heats up. This phenomenon also be reversed by changing the polarity of the applied DC voltage causing heat to flow in the opposite direction Thereby, a thermoelectric module may be used for both heating and cooling which makes it highly suitable for precise temperature control applications. Thermoelectric cooling systems have advantages over conventional cooling devices, such as compact in size, light in weight, high reliability, no mechanical moving parts and no working fluid.

KEYWORDS : Peltier Module, Thermoelectric Coolers (TECs), Semi conductor, DC voltage

1.INTRODUCTION:

Thermoelectric cooler is also called thermoelectric module or Peltrier coolers. They are semiconductor based electronic components that function as small heat pumps. On applying a low DC voltage to the thermoelectric module, heat moves through the module from one side to the other. One face of module is therefore cooled, while the other face simultaneously heats up Thermoelectric cooling, commonly referred to as cooling technology using thermoelectric coolers (TECs), has advantages of high reliability, no mechanical moving parts, compact in size and light in weight, and no working fluid. In addition, it possesses advantage that it can be powered by direct current (DC) electric sources, When a voltage or DC current is applied to two dissimilar conductors, a circuit can be created that allows for continuous heat transport between the conductors's junctions this is the principle of thermoelectric Cooler.

2. IDENTIFICATION OF PROJECT:

With excessive usage of fossil fuels for basically all purposes, even a slightest reduction in it would result in a large sum of annual savings and benefits to the environment. Thus, to reduce stress on fossil fuels, emphasis must be given to renewable energy resources. Solar energy is the most vulnerable and efficient renewable energy source. Though technology is yet being developed to harness these sources, the available methods are also quite efficient.

With this in mind, a solar photovoltaic based air-conditioning system needs to be developed. A basic schematic of the idea is presented below.

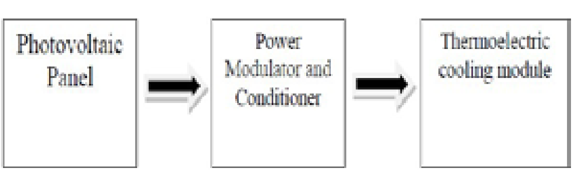

FIGURE 3: SCHEMATIC DIAGRAM OF PHOTOVOLTAIC BASED TEC

The primal motive of this project is aimed at improving fuel economy of a vehicle by shifting part or complete thermal load on to the thermoelectric devices rather than the conventional compressor based systems. But practical considerations and limitations do not allow the entire load to be shifted onto the thermoelectric modules, thus this system is going to be more or less a supplementary system to the main compressor based system.

The possible outcome of this project can improve fuel efficiency which can end up in drastic amount of saving in local (proprietary) or national economies.

3. LITERATURE REVIEW:

The Peltier effect is the presence of heating or cooling at an electrified junction of two different conductors and is named for French physicist Jean Charles AthanasePeltier, 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 is equal to,

$$Q = (\Pi_A - \Pi_B)I$$

Where Π is the peltier coefficient of the conductor And I is the electric current

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 $\Pi_A$and Π_B are different. The Peltier effect can be considered as the back-action counterpart to the Seebeck effect (analogous to the back-emf in magnetic induction): if a simple thermoelectric circuit is closed then the Seebeck effect will drive a current, which in turn (via the Peltier effect) will always transfer heat from the hot to the cold junction. The close relationship between Peltier and Seebeck effects can be seen in the direct connection between their coefficients: $\Pi=TS$

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 gain heat. Thermoelectric heat pumps exploit this phenomenon, as do thermoelectric cooling devices found in refrigerators.

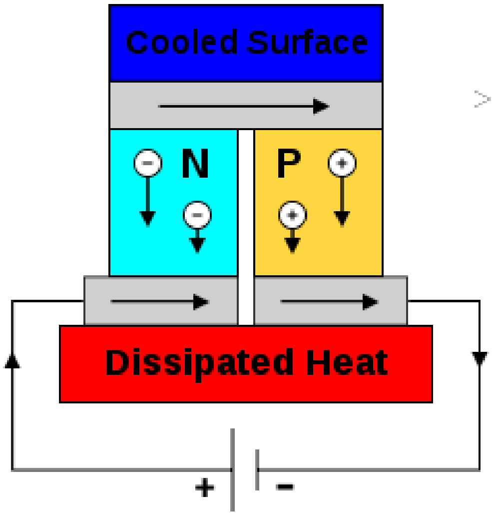

FIGURE 3.1: PELTIER EFFECT

Thermoelectric materials can be used as refrigerators, called "thermoelectric coolers", or "Peltier coolers" after the Peltier effect that controls their operation. As a refrigeration technology, Peltier cooling is far less common than vapor-compression refrigeration. The main advantages of a Peltier cooler (compared to a vapor- compression refrigerator) are its lack of moving parts or circulating fluid, and its small size and flexible shape (form factor). Another advantage is that Peltier coolers do not require refrigerant fluids, such aschlorofluorocarbons (CFCs) and related chemicals, which can have harmful environmental effects.

The main disadvantage of Peltier coolers is that they cannot simultaneously have low cost and high power efficiency. Advances in thermoelectric materials may allow the creation of Peltier coolers that are both cheap and efficient. It is estimated that materials with ZT >3 (about 20–30% Carnot efficiency) are required to replace traditional coolers in most applications. Today, Peltier coolers are only used in niche applications.

The Peltier effect can be used to create a refrigerator which is compact and has no circulating fluid or moving parts; such refrigerators are useful in applications where their advantages outweigh the disadvantage of their very low efficiency.

4. MATHEMATICAL MODELLING:
PELTIER MODULE HEAT SINK CALCULATIONS

With the increase in heat dissipation from electronics devices and the reduction in overall form factors, thermal management becomes a more a more important element of electronic product design. Heat sinks are devices that enhance heat dissipation from a hot surface, usually the case of a heat generating component, to a cooler ambient, usually air. For the following discussions, air is assumed to be the cooling fluid. In most situations, heat transfer across the interface between the solid surface and the coolant air is the least efficient within the system, and the solid-air interface represents the greatest barrier for heat dissipation. A heat sink lowers this barrier mainly by increasing the surface area that is in direct contact with the coolant. This allows more heat to be dissipated and/or lowers the device operating temperature. The primary purpose of a heat sink is to maintain the device temperature below the maximum allowable temperature specified by the device manufacturers.

Using temperatures and the rate of heat dissipation, a quantitative measure of heat transfer efficiency across two locations of a thermal component can be expressed in terms of thermal resistance *R*, defined as: $R = \Delta T/Q$

Where *T* is the temperature difference between the two locations. The unit of thermal resistance is in °C/W, indicating the temperature rise per unit rate of heat dissipation. This thermal resistance is analogous to the electrical resistance *Re*, given by Ohm's law, With *V* being the voltage difference and I the current.

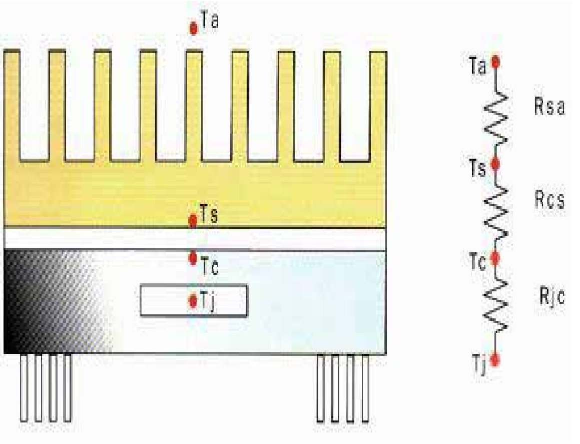

FIGURE : THERMAL RESISTANCE CIRCUIT

The thermal resistance between the junction and the case of a device is defined as:

$$Rjc = (Tjc)/Q = (Tj- Tc)/Q$$

This resistance is specified by the device manufacturer. Although the *Rjc*value of a give device depends on how and where the cooling mechanism is employed over the package, it is usually given as a constant value. It is also accepted that Rjc is beyond the user's ability to alter or control. Similarly, case-to-sink and sink-to-ambient resistance are defined as

$$Rcs = (\Delta Tcs)/Q = (Tc- Ts)/Q \quad Rsa = (\Delta Tsa)/Q = (Ts- Ta)/Q$$

respectively. Here, *Rcs*represents the thermal resistance across the interface between the case and the heat sink and is often called the interface resistance. This value can be improved substantially depending on the quality of mating surface finish and/or the choice of interface material. *Rsa*is heat sink thermal resistance.

To begin the heat sink selection, the first step is to determine the heat sink thermal resistance required to satisfy the thermal criteria of the component. By rearranging the previous equation, the heat sink resistance can be easily obtained as

$$Rsa = ((Ts - Ta)/Q) - Rjc- Rcs$$

In this expression, *Tj*, *Q* and *Rjc*are provided by the device manufacturer, and *Ta* and

*Rcs*are the user defined parameters.

5. RESULTS AND CONCLUSION:
RESULT

Peltier device: After correct isolation of each individual module we have observed a temperature drop of 9.3^0in 25 minutes. Upon reducing the volume of the box by approximately half, we have obtained a temperature drop of 10^0 in 25 minutes.

CONCLUSION:

From the above results we can conclude that the reliability of the peltier module available in India is less with unsatisfactory level of cooling.

Thus more research is required in the cooling module design with high quality Peltier modules to be made available from U.S or Europe.

If such changes are made than the rate of satisfactory results will surely increase with reliability.

The general system is simple to design yet performance of the entire system is yet to be realized.

Due to certain abnormalities we were unable to successfully interface the regulator circuit with the TEC and the solar panel.

In addition to this, a 255W solar panel is insufficient to power an air conditioning system, especially in automobiles. Therefore, more research is needed in the development of efficient photovoltaic material.

Furthermore, other factors like shading and effective mounting also hinder the performance of the PV system.

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