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Design and Fabrication of Solar Peltier Cooler

[1]Sanket Gayke, [2]Awdoot Kamble, [3]Bhavesh patil, [4]Atharva Lokhande, [5]Prof.A.P. Yadav

JSPM's Jaywantrao Sawant College of Engineering ,Hadapsar , Pune, Mah. India

Abstract:

Design and fabricating a new a complete photovoltaic solar system using thermoelectric methodis great difficult thing for small bottle cooling. This paper elaborates details of the new design details with all simplifications for the thermoelectric cooling system. This system will be very much useful military usage and remote areas mainly where there is issue of electricty. This system is made by a single stage Peltier coil.

Keywords: Peltier, heat flux, output power, refrigeration

Introduction:

To overcome the disadvantages of conventional refrigeration system where compact and portable refrigeration is required and to reduce the use of conventional domestic power supply by utilization of renewable energy source and there by reduction of components of the vapour compression cycle.

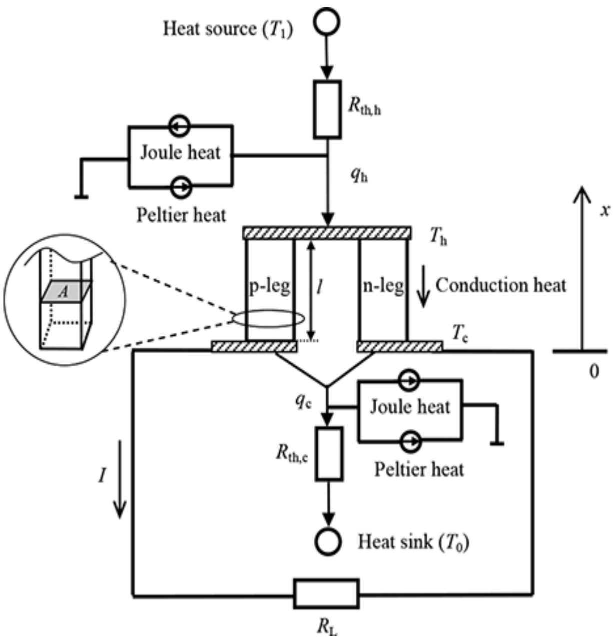


Figure 1.Structure and circuit sketch of TEG cell.

As a drastic increase of use in renewable energy sources in the commercial market various products are coming forward in order to reduce the conventional and non-renewable energy sources which can thereby reduce the problem of Global warming. As considering the consumer needs in daily life very less products are available in the market which can directly use the solar power and produce chilling effect quickly. Below product is the combined application of solar power, conventional domestic power supply and the principle of thermo-electric effect which brings forward a technique named Thermo-electric refrigeration and chilling effect.

Objectives

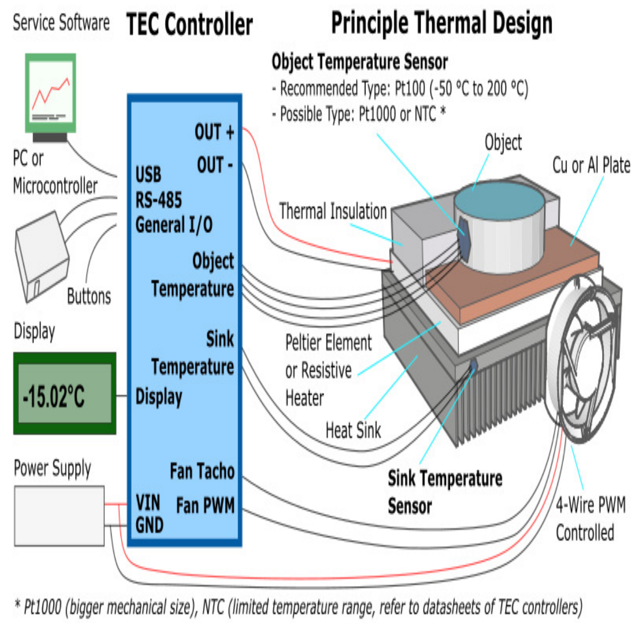
- To develop a compact refrigeration system by eliminating the conventional components.
- To reduce the domestic power supply and to use solar electric power eventually reducing overall cost.
- To achieve maximum evaporating temperature in minimum time.
- To develop an environment friendly product without using refrigerant.
- To achieve cooling at any desired time & location.

Methodology:

- Store the electricity from solar panel to the 12 v DC battery.
- The store electricity is further utilized for the operation of thermoelectric generator (TEG).
- The TEG is Peltier module which one side becomes cold and other side becomes hot after passing electricity.
- These cold side is used for the refrigeration purpose.
- The chilling effect achieved by the cold side is conducted to the aluminium container as the medium of chilling to the fluid and then the fluid is chilled due to the temperature drop by the aluminium container.

A Typical Thermoelectric System

Actual solar cooler model



Team-mate of the heat sink, is not visible. It's the ambient air with its temperature, where that heat will be dissipated. Some components are important in a total application. These are example temperature sensors, a software to configure and monitor the TEC controllers, a fan and of course the power supply.

Thermal Schematic: This schematic of a simple thermoelectric system shows the objects, involved in the path of the heat flowing from the object to the ambient air. This is simple layout where we assume perfect thermal insulator of the object, e.g. temperature of the object have no influence by convection. Where Q is = thermal capacity of each piece.

The cooling system and the corresponding temperature diagram seen at right. The object is cooled down to -5 °C in supoose, at cold side of the Peltier coil. The hot side of the Peltier coil at 35 °C. The heat sink dissipates the heat to the surrounding air = 25 °C.

Calculations:

Thermal parameters which to select a Peltier coil of highest cooling capacity Q_{max}, Temperature difference dT. Find Heat Load and get Temperatures. We got object with a heat load of **Q_C = 10 W** to cool to zero degrees .T_O = 0 °C .Room temperature got 25 °C and the heat sink temperature T_S got 30 °C. Temperature difference between the cold and hot side of Peltier coil dT found is 30 . To calculate dT as difference between ambient air temperature and desired object temperature by choosing a Peltier coil. We have to find a Q_{max} to cover the needed Q_C and yields better COP. We locate the maximum of the dT = 30 K curve at a current of **I/I_{max} = 0.45**. Normally, this ratio should not be higher than 0.7.

Using that factor for the current we find in the heat pumped vs. current graph the value $Q_C/Q_{max} = 0.25$ for the given temperature difference dT = 30 K and relative current of 0.45.

Now calculate Q_{max} for the Peltier coil $Q_{max} = Q_C / 0.25 = 10\ W / 0.25 = 40\ W$. In the performance vs. current graph we find COP = 0.6 for our previously read out I/I_{max}. This tells us to calculate $P_{el} = Q_C / COP = 10\ W / 0.6 = 16.7\ W$. Peltier coil manufacturers offer a wide range of elements. Element with a Q_{max} of 40 W. As we get a temperature difference of dT = 30 K, a single stage Peltier coil is sufficient. We selected Peltier element with Q_{max}=41 W, dT_{max}=68 K, I_{max}=5 A and V_{max}=12 V. The current and voltage are calculated as follows:

$I = I_{max} * (I/I_{max}) = 5\ A * 0.45 = 2.25\ A$

$V = P_{el} / I = 16.7\ W / 3.83A = 7.42\ V$

Selecting a battery: Based on the calculated values, we select battry of 2500mah with 4 A output current and 12 V output voltage.

Heat Sink: To find a heat sink for the Peltier coil , we need to know the required thermal resistance of the heat sink. In the heat rejected vs. current graph we find Q_h / Q_{max}=0.6 for our chosen current and dT. Thus, $Q_h = Q_{max} * 0.6 = 41\ W * 0.6 = 24.6\ W$.

Calculation of the heat sink thermal resistance: $R_{thHS} = \Delta T_{HS} / Q_h = 5\ K / 24.6\ W = 0.2\ K/W$ We need a heat sink with a thermal resistance smaller than 0.2 K/W.The above calculations are a first estimation of the parameters for a thermoelectric cooling system. Testing of a real system and iterating through the design steps is necessary to determine optimal system parameters.

Scope:

- By use of solar panels, charge the bottle in the presence of solar energy and even charge the bottle using the available power source anywhere and anytime.
- The bottle can be carried anywhere like any other bottle due to its compact size and the chilled water/beverage is ready in some seconds.
- As moving components are less, so the noise and vibrations are negligible which increases the life of the product.
- The product is very likely to be useful in the hot areas as there are less and costly methods for refrigeration and chilling and it can be carried anywhere as the product is portable.

Conclusion:

Peltier based solar cooled bottle is designedand manufactured successfully to get expected cooling effect.Current generated 2.25 Amp.voltage generated 12volt with 7.42volt utilization by peltier coil.coficient of performance 0.6.with total system wattage 10W.

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