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Solar Powered Thermal Jacket For Soldiers in Extreme Temperatures

Ch.Sabarish
Department of Mechanical Engineering
Malla Reddy Engineering College, Hyderabad.

R.S.Reddy, M.Tech, Ph.D
Professor,
Department of Mechanical Engineering
Malla Reddy Engineering College, Hyderabad.

Abstract:

Soldiers are the Army's most important resource and the back bone to keep the nation's peace intact. They will always be the one responsible for taking and holding the duty in extreme weather conditions throughout the year. While providing security to the nation, they may face troubles in extreme hot or cold weather conditions. We have designed and produced a solar powered thermal jacket which gives better protection to them who are working in extreme weather conditions. Here we used a peltier plate of 5V, 500mA supply for cooling and heating the jacket. This peltier plate, mainly called as thermo electric cooler, will be powered by a flat plate solar panel. A 12 V Direct Current lead acid rechargeable battery is used for storing the energy.

Keywords:

Peltier Plate;Thermo Electric Cooler(TEC); Flat Plate Solar Panel; lead acid rechargeable battery.

I. INTRODUCTION:

Solar energy is radiant light and heat from the sun harnessed using a range of ever-evolving technologies such as solar heating, solar photovoltaics, solar thermal energy, solar architecture and artificial photosynthesis. It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on the way they capture and distribute solar energy or convert it into solar power. Active solar techniques include the use of photovoltaic systems, concentrated solar power and solar water heating to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air [1].

The Earth receives 174 PetaWatts (PW) of incoming solar radiation at the upper atmosphere. Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses.Earth's land surface, oceans and atmosphere absorb solar radiation, and this raises their temperature. Warm air containing evaporated water from the oceans rises, causing atmospheric circulation or convection. When the air reaches a high altitude, where the temperature is low, water vapor condenses into clouds, which rain onto the Earth's surface, completing the water cycle [4].

II.THERMOELECTRIC COOLING:

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 Thermo Electric Cooler (TEC). It can either be used 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 [2].

A Peltier cooler can also be used as a thermoelectric generator. When operated as a cooler, a voltage is applied across the device, and as a result, a difference in temperature will build up between the two sides. When operated as a generator, one side of the device is heated to a temperature greater than the other side, and as a result, a difference in voltage will build up between the two sides (the Seebeck effect). However, a well-designed Peltier cooler will be a mediocre thermoelectric generator and vice versa, due to different design and packaging requirements.

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A. Operating principle:

Fig.1 shows the working of Thermoelectric coolers by the Peltier effect (which also goes by the more general name thermoelectric effect). The device has two sides, and when DC current flows through the device, it brings heat from one side to the other, so that one side gets cooler while the other gets hotter. The "hot" side is attached to a heat sink so that it remains at ambient temperature, while the cool side goes below room temperature. In some applications, multiple coolers can be cascaded together for lower temperature [2].

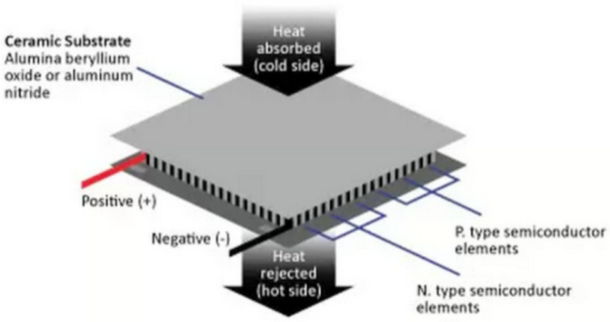

Fig. 1.Schematic layout of peltier plate

B. Construction of thermo electric cooler:

Fig.2 shows two unique semiconductors, one n-type and another p-type, are used because they need to have different electron densities. The semiconductors are placed thermally in parallel to each other and electrically in series and then joined with a thermally conducting plate on each side. When a voltage is applied to the free ends of the two semiconductors there is a flow of Direct Current (DC) current across the junction of the semiconductors causing a temperature difference. The side with the cooling plate absorbs heat which is then moved to the other side of the device where the heat sink is provided. TECs are typically connected side by side and sandwiched between two ceramic plates. The cooling ability of the total unit is then proportional to the number of TECs in it [2].

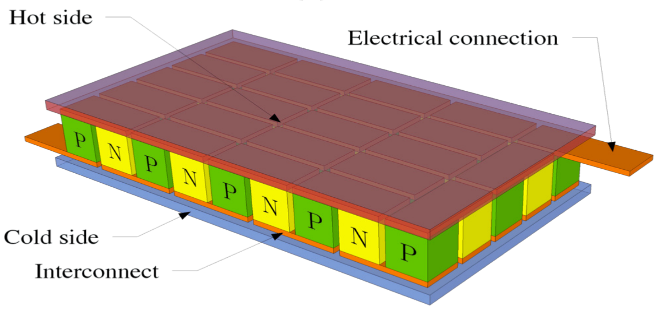

Fig. 2.Operating principle of thermo electric cooler and heater

III.EXPERIMENTAL SETUP:

The experimental setup in this project consists of

A. Rechargable Battery:

A rechargeable battery or storage battery is a group of one or more electrochemical cells. They are known as secondary cells because their electrochemical reactions are electrically reversible. Rechargeable batteries come in many different shapes and sizes, ranging anything from a button cell to megawatt systems connected to stabilize an electrical distribution network. Several different combinations of chemicals are commonly used, including: lead-acid, nickel cadmium(NiCd), nickel metal hydride (NiMH), lithium ion (Li-ion), and lithium ion polymer (Li-ion polymer) [5].

B. Solar Panel:

Fig.3 shows the solar panel used in the project. Solar panels are devices that convert light into electricity. Solar panels make use of renewable energy from the sun, and are a clean and environmentally sound means of collecting solar energy. A solar panel is a collection of solar cells. Lots of small solar cells spread over a large area can work together to provide enough power to be useful. The more light that hits a cell, the more electricity it produces.

Solar panels can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions, and typically ranges from 100 to 320 watts. The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module. Solar modules use light energy (photons) from the sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells based on cadmium telluride or silicon. The structural (load carrying) member of a module can either be the top layer or the back layer.

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Cells must also be protected from mechanical damage and moisture. Most solar modules are rigid, but semi-flexible ones are available, based on thin-film cells. Electrical connections are made in series to achieve a desired output voltage and/or in parallel to provide a desired current capability. The conducting wires that take the current off the modules may contain silver, copper or other non-magnetic conductive transition metals. The cells must be connected electrically to one another and to the rest of the system.

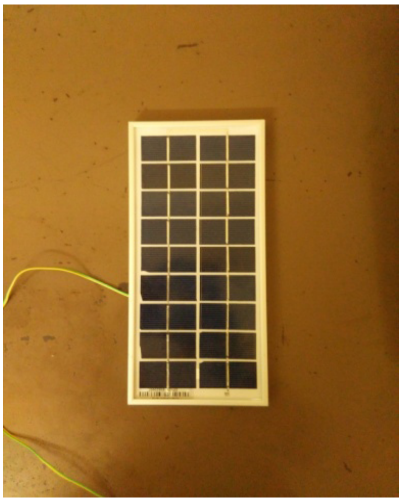

Fig. 3.Solar panel used in project

C.Peltier Plate:

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 side against the temperature gradient (from cold to hot), with consumption of electrical energy. Such an instrument is also called a Peltier device, Peltier heat pump, solid state refrigerator, or thermoelectric cooler (TEC). The Peltier device is a heat pump: when direct current runs through it, heat is moved from one side to the other. Therefore it can be used either for heating or for cooling (refrigeration), although in practice the main application is cooling. It can also be used as a temperature controller that either heats or cools. The most common temperature control option for the AR rheometers is the Peltier Plate. The AR-G2, AR 2000ex and AR 1500ex Peltier plates have a temperature range of -40°C to 200°C with a typical heating rate of up to 20°C /min. and a temperature accuracy of +/- 0.1°C.

A PRT (platinum resistance thermometer) sensor positioned at the center of the plate ensures accurate temperature measurement and control. A peltier cooler is a cooler that uses a Peltier element (TEC). Peltier coolers consist of the Peltier element itself, and a powerful heat sink fan combination to cool the TEC. The typical maximum temperature difference between the hot side and the cold side of a TEC, referred to as delta Tmax, is around 70°C. This does not mean that simply adding a Peltier element between heat sink and heat source will cause the temperature of the cooled device to drop by 70°C [1].

IV.RESULTS AND DISCUSSION:

Table I shows different types of absorptive coatings and their effectiveness. It clearly states that Black chrome over nickel is most efficient and has higher break down temperature. The emittance of black chrome over nickel is very low comparatively, that means losses are less. The temperature this type of coating can handle is 450oc.

TABLE I. CHARACTERISTICS OF ABSORPTIVE COATINGS:

Material	Absorptance	Emittance	Break Down Temperature (°C)	Comments
Black silicon paint	0.86-0.94	0.83-0.89	350	Stable at high temperature
Black copper over copper	0.85-0.9	0.08-0.12	450	Patinates with moisture
Black chrome over nickel	0.92-0.94	0.07-0.12	450	Stable at high tempera tures

Table II gives the characteristics of insulation materials which is fiber glass with organic binder. The thermal conductivity and temperature limits vary whit change in density of the insulation material.

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TABLE II. CHARACTERISTICS OF INSULATION MATERALS:

Material	Density,Kg/m3	Thermal conductivity at 95 °C (W/mK)	Temperature Limits,°C
Fiber glass with organic binder	11	0.059	175
	16	0.050	175
	24	0.045	175
	48	0.43	175

Fig.4 shows the final result of the project. It has a thermal jacket with a peltier plate integrated in it.

Fig. 4.Thermal Jacket Setup.

V. CHALLENGES:

The main and the only challenge faced during the work is the Peltier plate. The main concept of the Peltier plate is the change in direction of current results in the one side heating and other side cooling of the plate. As the plate is required to be cool in hot weather conditions the heat of the plate on the other side is conducted to the other side.

As a result the total plate is heated which results in the failure of the project. To overcome this problem a heat sink is introduced to the hot side of the plate through which the unwanted heat is dissipated. Fig 5 shows the heat sink used to overcome the challenge.

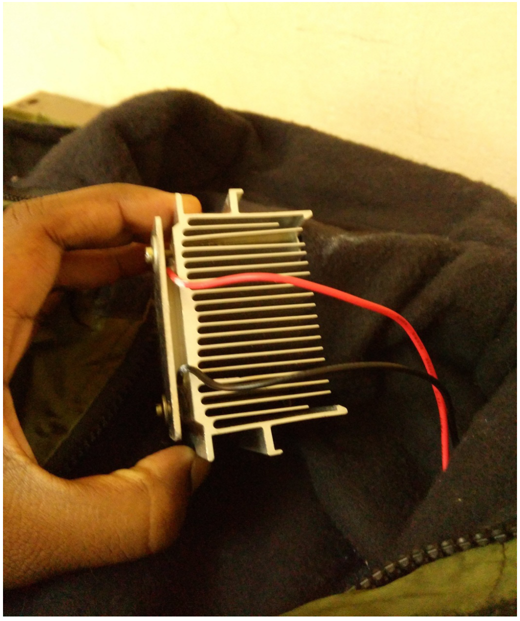

Fig. 5.Heat Sink for the Peltier Plate

As only one Peltier plate is integrated in the jacket the heat or cold cannot be transferred totally through the jacket. So, more than one Peltier plate should be used in the jacket. This in turn increases the weight and cost factors. The only way to overcome this problem is to use pneumatic boots in the center layer of the jacket. A pneumatic boot is a balloon kind of thing which can be filled with air. Even if one Peltier plate is used the air inside the boots helps in transfer of heat or cold through the jacket.

VI. CONCLUSION:

The project "Solar powered thermal jacket for soldiers in extreme temperatures" is successfully tested. By using this project in real time applications the thermal jacket can help soldiers to work even in extreme weather conditions. It is a highly durable and self-repairing solar technology, ideally suited for mobile applications. Combined with integrated charge control and optional battery/charger systems, it provides the conveniences of back-up and always ON, on-demand small scale solar electrical power.

VII. REFERENCES:

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