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ANALYSIS OF SOLAR REFRIGERATION SYSTEM USING THERMO ELECTRIC COOLING (TEC) MODULE

Sutar Rajshekhar Manohar
Final year Engineering student of A.G.P.I.T, Solapur

Rajamane Nitish Mallikarjun
Final year Engineering student of A.G.P.I.T, Solapur

Gobbur Akshay Sidharam
Final year Engineering student of A.G.P.I.T, Solapur

Gadkar Pradip Vyankatesh
Final year Engineering student of A.G.P.I.T, Solapur

Dulange S. R.
Professor, Department of Mechanical Engineering, A.G.P.I.T,
Solapur, Maharashtra.

ABSTRACT

A refrigerator is a common house hold appliance that consists of a thermally insulated compartment and a heat pump that transfer heat from the inside of the refrigerator to its surrounding so that the inside of the refrigerator is cooled to a temperature below the ambient temperature of the room. Thermoelectric Cooling (TEC) solar refrigerator runs on energy provided by sun, which includes photovoltaic or solar thermal energy. Peltier Jean (1834) discovered the Thermoelectric (TE) property about two centuries ago; thermoelectric device have commercialized during recent years. The applications of TE vary from small to large refrigerators. The Thermoelectric module refrigerator work on the principle of Peltier effect. Recently, the application of TEC modules in an industry is dramatically increased. They have been adopting the solar refrigeration, widely recognized as alternative to the conventional vapour compression system for their merits of energy saving and being eco-friendly. The paper presents a design of TEC solar refrigeration using thermoelectric cooling. The objective of this paper is to establish an alternative eco-friendly refrigeration cycle for producing a temperature usually encountered in a conventional refrigerator. By designing and manufacturing such type of refrigerator adds new dimension to the world of refrigeration. The proposed solar refrigeration system using TEC module is a feasible alternative for local refrigeration system. Briefly, the paper presents an economical and feasible model of solar refrigeration system.

KEY WORDS - Peltier effect, thermoelectric module, eco-friendly.

INTRODUCTION

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 Peltier device, Peltier heat pump, solid-state refrigerator, or thermoelectric cooler (TEC). It was 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.This technology is far less commonly applied to refrigeration than vapour-compression refrigeration is. The primary advantages of a Peltier cooler compared to a vapour-compression refrigerator are its lack of moving parts or circulating liquid, very long life, invulnerability to leaks, small size and flexible shape. Its main disadvantage is high cost and poor power efficiency. Many researchers and companies are trying to develop Peltier coolers that are both cheap and efficient.
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.
In recent year, the EPA has phased out the use of R-12 Freon in all refrigeration system and R-134 has become the new standard. If you have an older system with R-12 you may need to retrofit your system to handle the new R-134 refrigerant. Sometimes seals hoses and even the compressor need to be changed. The problem arises when the older seals and hoses are not compatible with the new oils found in the R-134.
Corrosion will Cause the heater core to leak. This will manifest itself by leaving steam into the passenger compartment and fogging your windows. You will know there is a leak by the sweet smell coming from your vents. Unfortunately changing the heater core is usually not the easier job in the world as engineer tends to squeeze them into some pretty tight space under the dash. by using wind power, Wind power is extracted from air flow using wind turbines or sails to produce mechanical or electrical power. Windmills are used for their mechanical power, wind pumps for water pumping, and sails to propel ships. Wind power as an alternative to fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, and uses little land. The net effects on the environment are far less problematic than those of non-renewable power sources. Wind farms consist of many individual wind turbines which are connected to the electric power transmission network. Onshore wind is an inexpensive source of electricity, competitive with or in many places cheaper than coal or gas plants. Offshore wind is steadier and stronger than on land, and offshore farms have less visual impact, but construction and maintenance costs are considerably higher. Small onshore wind farms can feed some energy into the grid or provide electricity to isolated off-grid locations. Wind power is very consistent from year to year but has significant variation over shorter time scales. It is therefore used in conjunction with other electric power sources to give a reliable supply. As the proportion of wind power in a region.
Increases, a need to upgrade the grid, and a lowered ability to supplant conventional production can occur. Power management techniques such as having excess capacity, geographically distributed turbines, dispatch able backing sources, sufficient hydroelectric power, exporting and importing power to neigh boring areas, using vehicle-to-grid strategies or reducing demand when wind production is low, can in many cases overcome these problems. In addition, weather forecasting permits the electricity network to be readied for the predictable variations in production that occur. A heat sink is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device into a coolant fluid in motion. Then-transferred heat leaves the device with the fluid in motion, therefore allowing the regulation of the device temperature at physically feasible levels. In computers, heat sinks are used to cool central processing units or graphics processors.
Heat sinks are used with high-power semiconductor devices such as power transistors and optoelectronics such as lasers and light emitting diodes (LEDs), where the heat dissipation ability of the basic device is insufficient to moderate its temperature. cabinet may be crate by Plastic is a material consisting of any of a wide range of synthetic or semi-synthetic organics that are malleable and can be moulded into solid objects of diverse shapes. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural. Plasticity is the general property of all materials that are able to irreversibly deform without breaking, but this occurs to such a degree with this class of mouldable polymers that their name is an emphasis on this ability.

LITERATURE REVIEW

1)"Performance Evaluation of a Thermoelectric Refrigerator", Onoroh Francis, Chukuneke Jeremiah Lekwuwa, Itoje Harrison John International Journal of Engineering and Innovative Technology (IJEIT) Volume 2. From above research paper we have studied about the Seebeck effect, thermoelectric refrigerator, hybrid refrigerator and thermo electric materials. Thermoelectric cooling provides a promising alternative R&AC technology due to their distinct advantages. Use of Thermoelectric effect to increase the COP of existing cooling system.
2)"Design and Development of Thermoelectric Refrigerator ", Mayank Awasthi International journal of mechanical engineering and robotics.From above research paper we have studied about thermoelectric component like heat sink. The design requirements are to cool this volume to temperature within a less time period and provide retention of at least next half an hour. The design requirement, options available.
3) "A Review on use of Peltier Effects ",Ajitkumar Nikam Dr.Jitendra hole Mechanical Engineering Department, Rajashri Shahu college of engineering ,Pune.From above research paper we have studied about use of peltier plate in refrigerator. 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.
4) Solar Energy for Cooling and Refrigeration Dr. R.E. Critoph and Mr. K. Thompson Engineering Department, University of Warwick, Coventry CV4 7AL, UK. From this research paper, the need to replace the peak load

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demand for electricity for air conditioning applications coupled with the desire of gas utilities to balance their heating loads with a summer alternative has lead to the development of heat powered refrigeration cycles. The result has been research into improved desiccant materials and cycles to both improve performance and reduce costs.

5)WHO report EPI/ CCIS/85.4, 'Solar powered refrigerator for vaccine storage and icepack freezing, Status summary June 1986', 1986. This paper describes how to calculate vaccine volumes at each level of the cold chain. It is an important document for anyone involved in planning and buying equipment for storing and transporting vaccines.

CONCEPT OF PROJECT

3.1. ASSUMPTION

Before making decisions on which components to use for the box, theory had to be reviewed and some preliminary calculations performed.

3.2. PASSIVE HEAT LOAD

The passive heat load for the unit was first calculated based upon a 25cm x 25cm x 25cm interior volume. Two inches of polystyrene insulated was assumed (k=0.027w/mK). Also included were a rubber seal on the door which was 50 cm2 in area.

$$q_{tot} = k_{ins}\frac{\Delta T}{\Delta x} + k_{rubber}\frac{\Delta T}{\Delta x}$$

where: q_{tot} is the heat transfer in watts, k_{ins} is the resistance to heat transfer, and k_{rubber} is 0.014w/mK
ΔT is assumed to be 20 °C and Δx is 0.50m.

This gives a q_{tot} of 10 W.

3.3. ACTIVE HEAT LOAD

The active heat load is the equivalent of the cooling power that the unit will need to provide when the sample at room temperature is placed in the container. It was decided that one litter of water at room temperature would be the test sample for which all calibration and calculations would be made. The time to cool this load from 25 °C to 5 °C was determined to be 1 hour, or 3600 seconds. Based on these values:

$$Q = c_p m \Delta T$$

If the Cp of water is 4.14 KJ/kg*K, then Q = 82800J and dividing by 3600s to get power (W), Q_{dot}

= 23 W for the active heat load. Therefore, the total load is 23 + 11 W = 34 W of power required. This assumes that there is no thermal resistance between the sample and the air in the unit. This may be an incorrect assumption but it does overestimate the cooling load.

3.4. HEAT LOAD REQUIRED TO BE DISSIPATED BY HEAT SINK

The Peltier module is running at 12V and 5.2 amps of current. The following V_{in} vs. I graph[1] shows a normal operating range of the TEM.

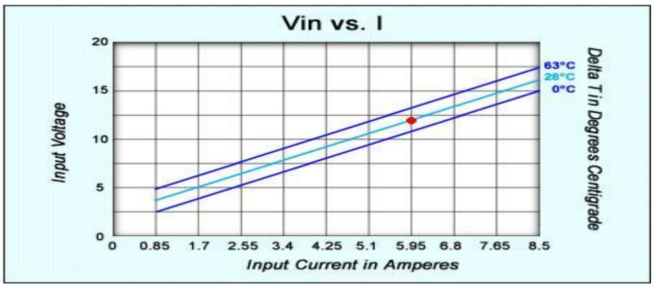

Figure 1: Thermoelectric Module Performance

The power consumed by the TEM is assumed in the worst case scenario to be added to the heat on the hot side. Division by two denotes that we have two TEM's, two hot side heat sinks and two cold side heat sinks to improve system efficiency. Therefore, q_{tot}= 107W. This is the maximum heat load to the hot side of each TEC and therefore each of the heat sinks.

$$q_{hot} = P_{TEC} + \frac{Q_{passive} + Q_{sample} + Q_{safetyfactor}}{2}$$

3.5. MAXIMUM TEMPERATURE RISE ON HOT SIDE OF TEC

Max temp rise = 107W x 0.17 °C/W = 18.2 °C

The ΔT over the TEC is 25 – 5 +18.2 (°C) = 38.2 °C, where 25 is the ambient temperature on the hot side, 5 is inside desired temperature and 18 is the added heat load.The following table will show that the operating point for heat removal of 18W (for each TEC) and a ΔT of 38°C
only requires a current draw of 4.5Amps.

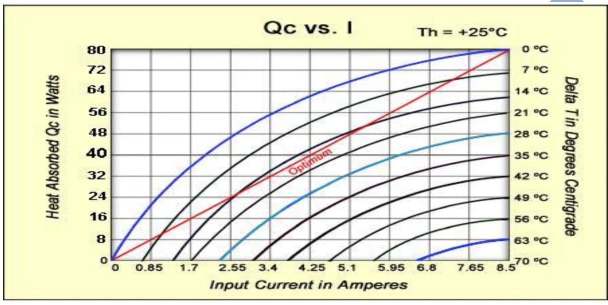

Figure 2: Thermoelectric Performance Graph

3.6. THERMOELECTRIC COOLING

A standard module consists of any number of thermocouples connected in series and sandwiched between two ceramic plates By applying a current to the module one ceramic plate is heated while the other is cooled. The direction of the current determines which plate is cooled. The number and size of the thermocouples as well as the materials used in the manufacturing determine the cooling capacity. Cooling capacity varies from fractions of Watts up to many hundreds. Different types of TEC modules are single stage, two stage, three stage, four stage, centre hole modules etc. Pumping capacities

Figure 3: Thermoelectric Module

3.7. THERMOELECTRIC COOLING, HEATING

When DC voltage is applied to the module, the positive and negative charge carriers in the pellet array absorb heat energy from one substrate surface and release it to the substrate at the opposite side. The surface where heat energy is absorbed becomes cold; the opposite surface where heat energy is released becomes hot. Using this simple approach to "heat pumping", thermoelectric technology is applied to many widely varied applications– small laser diode coolers, portable refrigerators, scientific thermal conditioning, liquid coolers, and beyond.

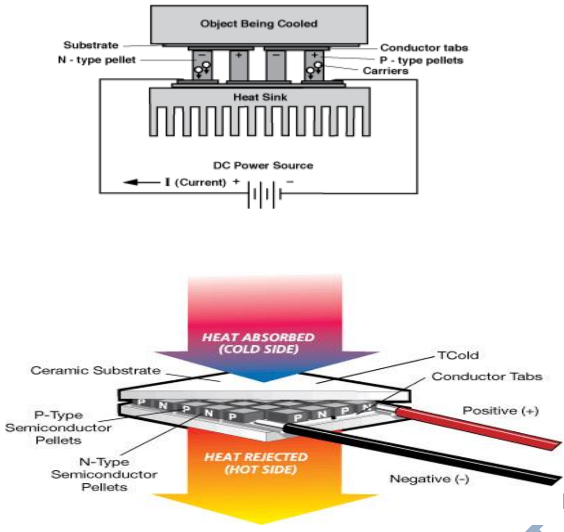

Figure 4: Thermoelectric Module Cooling, Heating.

Each individual thermoelectric system design will have a unique capacity for pumping heat (in Watts or BTU/hour) and this will be influenced by many factors. The most important variables are ambient temperature, physical & electrical characteristics of the thermoelectric modules employed, and efficiency of the heat dissipation system (i.e., sink). Typical thermoelectric applications will pump heat loads ranging from several mill watts to hundreds of watts.

3.8. THE THERMOELECTRIC "SWEET SPOT"

The majority of practical applications for thermoelectric technology fall within a very narrow Range of operating conditions.

• Temperature differential (Delta T) between 30°C and 50°C
• Thermoelectric module current draw (l) between 70% and 80% of IMAX, and
• Co-efficient of performance (COP) between 0.25 and 0.4.

WORKING

The project implemented a structured system analysis and design methodology approach to achieve the project objectives. Block system analysis of the project is shown below (Figure 1) with the aid of a straightforward block diagram. The blower through a duct blows out ambient air to the TECs. TECs are sandwiched in between heat sinks. Cold air is blown out from one end of the cold heat sinks. The TECs were powered by a power supply.

The cooling system mainly consists of the following modules Blower which acts as the primary source of air.

1. Duct, which conveys the air from the blower to cluster of Al cold heat, sinks.
2. One long heat sink is fitted to the hot side of TEC to absorb heat.
3. Six Aluminium heat sinks that are attached to the cold and hot side of TEC modules.
4. Three TECs are sandwiched between cold and hot heat sinks.
5. An DC source which is used to power the fans and blower. (Car Battery)
6. Dc power supply is used to drive the TECs

A simple on off temperature controller is built with the dc power supply, Thermoelectric Air Cooling For Cars. To design a cooling system using thermoelectric cooler (TEC) one has to know the basics of thermoelectric effect, thermoelectric materials and thermoelectric cooling. Thermoelectric effect can be defined as the direct conversion of temperature difference to electric voltage and vice versa. Thermoelectric effect covers three different identified effects namely, the Seebeck effect, Peltier effect and the Thomson effect. A thermoelectric device will create a voltage when there is temperature difference on each side of the device. On the other hand when a voltage is applied to it, a temperature difference is created. The temperature difference is also known as

Peltier effect. Thus TEC operates by the Peltier effect, which stimulates a difference in temperature when an electric current flows through a junction of two dissimilar materials. A good thermoelectric cooling design is achieved using a TEC, which is solid state electrically driven heat exchanger. This depends on the polarity of the applied voltage. When TEC is used for cooling, it absorbs heat from the surface to be cooled and transfers the energy by conduction to the finned or liquid heat exchanger, which ultimately dissipates the waste heat to the surrounding ambient air by means of convection.

4.1. HEAT SINK

A heat sink is designed to maximize its surface area in contact with the cooling medium surrounding it, such as the air. Air velocity, choice of material, protrusion design and surface treatment are factors that affect the performance of a heat sink.

Figure 5: Thermoelectric Module with Cooling fan.

Heat sink attachment methods and thermal interface materials also affect the die temperature of the integrated circuit. Thermal adhesive or thermal grease improve the heat sink's performance by filling air gaps between the heat sink and the heat spreader on the device.

4.2. HEAT SINK SELECTION

The values identified in the preceding first pass analysis are used to assess overall system feasibility. We want to qualify our assumption of 15°C rise across heat sink. The hot side temperature will be equal to the ambient temperature (TA) plus the rise in temperature across the heat sink from dissipating the heat load (Q) and the heat resulting from the thermoelectric module electrical power (V x I).

$$TH = TA + (V \times I + Q) RQ$$

where RQ = thermal resistance of heat sink in C° temperature rise per Watt dissipated.

The heat pumping capability of the thermoelectric module is significantly influenced by the efficiency of the heat sink. The hot side of the module must interface with an efficient heat removal system to achieve useful temperature differential across the thermoelectric module. Natural convection, forced convection, and liquid cooled are three of the most common types of heat sinks. Thermal resistance varies among the different types and sizes of sinks with natural convection being the least efficient and liquid cooled the most efficient. The majority of thermoelectric cooling applications use forced convection heat sinks with thermal resistance values (RQ) ranging from 0.05°/W to 0.9°/W.

Using values now known for TA V, I, and Q we can solve for RQ to determine if it is reasonable:

$$RQ = (TH - TA)/(V \times I + Q) = (50°C - 35°C)/(11V \times 3 \text{ amps} + 20W)$$

$$RQ = 0.283°C/W$$

Our proposed system using a C2-40-1504 module and a forced convection sink/fan combination meets or exceeds the criteria for this application. An experienced heat sink supplier can help with the selection of a system that meets the RQ requirements.

SYSTEM ASSEMBLY

Several methods for installing thermoelectric modules have been developed, including: mechanical clamping, epoxy bonding, and direct solder bonding. The individual requirements of the application will determine which method is most appropriate, mechanical clamping is by far the most common.

Thermoelectric modules are relatively strong in compression and weak in shear; whichever method of installation is used, it is important to avoid excessive mechanical loading of the module.

MECHANICAL CLAMPING:

1. Recommended flatness of interface surfaces should be within 0.001" and free of dirt, burrs etc.
2. Thermal interface materials must be used to fill in the small thermal gaps of Choices include silicone-based thermal grease, graphite foil, and thermally conductive pads. Refer to your interface material specifications for performance curves in relation to pressure.
3. Bolt the object to be cooled and heat sink together using stainless steel fasteners washers and or split type lock-washers, compression springs or Bellville washers can also be used.
4. The recommended compression loading is 70 to 150 per sq. inch of module surface.
5. Insure an even pressure across the module surface when tightening the screws.

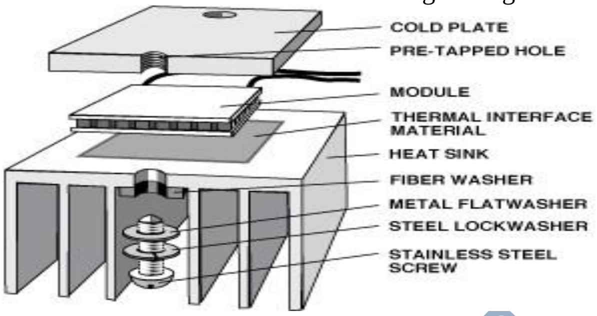

Figure 6: Mechanical Clamping of Thermoelectric Module.

SCOPE

1. In these days the society face the energy crisis but also the harmful effects of pollution. The thermoelectricity is a “Green Technology” to generate electricity without any harmful effect.
2. The educational institutions, furnace regions, metro cities, industrial areas, universities and other locations can be selected for the establishment of such energy centres where the waste heat can be easily available and can be recycled after conversion to the same system.
3. This system would be used for air ventilation in car.
4. This system is boost for government policies like solar cities and solar cities as well.

PROBLEM STATEMENT

1. The conventional system is highly consuming in household appliances.
2. Conventional refrigerator is space consuming.
3. Conventional system is only operating on AC supply only.
4. Conventional system is does not working on DC supply and batteries.
5. The cost of conventional system is high.
6. Refrigerant is present in conventional system that's why chances of leakages.
7. Conventional system increases the global warming by realizing the CO_2 in atmosphere.
8. Does have alternative during electricity unavailability.

OBJECTIVE

1. To study critically existing Refrigeration system for its advantage and disadvantages.
2. To explore various technological option to replace existing Refrigeration system.
3. To study TEC as a substitute for present Refrigeration system which will overcomes the all demerits of present Refrigeration system.
4. To fabricate working model of Refrigeration using TEC. To test Refrigeration using TEC for its effectiveness, efficiency, environment friendliness, comfort and convenience.

DESIGN

1: Understand the load: You must determine how much work the thermoelectric system must do to achieve the goal.

2: Select your thermoelectric device: Choose a thermoelectric device that can do the work you have determined while operating in the worst case scenario. Choose the module that can do this while operating in the "sweet spot" of 70-80% of Imax.

3: Select the level of corrosion, and dielectric protection: Choose the level of protection needed for your operating conditions.

4: Select your heat sink: Determine what heat sink performance is needed to achieve the goal, and source the proper device.

5: Assemble your system: A properly designed and assembled system will provide even clamping force, good thermal interface, proper sized thermoelectric module, adequate heat sinking, proper corrosion resistance, and insulation as needed

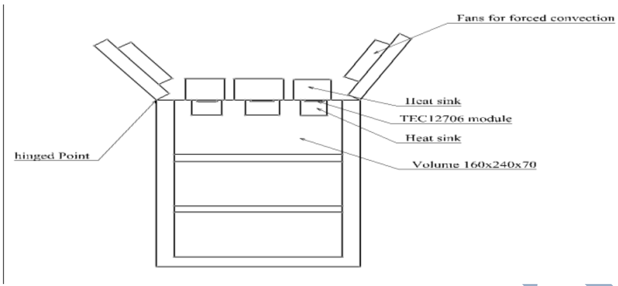

Figure 7: Construction.

ADVANTAGES

1. It saves electrical power supply.
2. It is the portable system.
3. Energy efficient system.
4. Eco-friendly system.
5. It has given an option to the use of refrigerant by the TEC module.
6. Ultimately it reduces the harmful effects which are occurred by the refrigerant.
7. It is the clean source of energy.
8. excess power produced by the refrigerator can be used for the other domestic purpose.
9. solar refrigerator can be very useful in far off remote places where there is no continuous supply of electricity.

LIMITATIONS

1. Refrigeration rate is quite slow.
2. Time consuming system.
3. Costly system.

COSTING

Table 1: Cost of Material Total Cost

Sr. No.	**Component**	**Quantity**	**Costing/piece**	**price**
1.	TEC module	04	650	
2.	Ply wood	8x4	2250	2250
3.	Heat sink aluminium	6	350	2100
4.	Cooling fans	02	390	780
5.	Solar panel	10watt	1850	1850
6.	Solar Controller	01	750	750
7.	SMPs 12 volt ,33 Amp	01	3150	3150

Total project cost =
[Total material cost] + [Total Labor Cost] + [Total Machining cost] + [Total Transportation Charges]
= [11130] + [3600] + [1950] + [2500]
=19180/-

CONCLUSION

It will have proposed that a hybrid solar refrigeration system is a feasible alternative for local refrigeration system. The following conclusions are drawn. The hybrid solar refrigeration system can be a replacement for conventional refrigeration. The hybrid solar refrigeration system works efficiently than conventional one. It can possible hybrid solar refrigeration system is alternative to reduce the co2 emissions and electricity demand when they driven by solar energy.

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