Design and Fabrication of Mini Refrigerator with Thermoelectric Cooling

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***Abstract*:- The impact of on-going progress in science and technology has created a variety of system that can be used in producing of refrigerator effect with the use of thermoelectric cooling. Such an instrument is also called a pettier heat pump, solid state refrigerator. It can be used either for heating or for cooling-although in practice the main applications is cooling. It can also be used as a temperature controller that either heats or cool. It has the advantage of having no moving parts and thus maintenance free. Thermoelectric refrigeration is a new alternative because it can reduce the use of electricity to produce cooling effect and also meet today's energy challenges. Therefore, the need for thermoelectric refrigeration in developing countries is very high where long life and low maintenance are needed. The objectives of this study is to develop a working thermoelectric refrigerator to cool a volume of 40 L that utilizes the Peltier effect to cool and maintain a selected temperature range of 3 0C to 23 0C. The design requirements are to cool this volume to temperature within a short time and provide retention of at least next half an hour. The design and fabrication of thermoelectric refrigerator for required applications are presented.**

Keywords-Seebeck Effect, Peltier Effect, Thermoelectric module

I. INTRODUCTION

when a circuit of two dissimilar metal and two junction is formed a current will flow between the junction or the circuit. This phenomenon is known as the see back effect. C. peltier , a french watchmaker and an amateur scientist discovered a reverse effect of the See back. He discovered that using joined dissimilar metals heat pump can be made Due to the increasing demand for refrigeration in various fields led to production of more electricity and consequently more release of harmful gas like CO2 all over the world which is a contributing factor of global warming on climate change. Thermoelectric refrigeration is a new alternative method. The thermoelectric modules are made of semiconductor materials electrically connected in series configuration and thermally in parallel to create cold and hot surfaces. Although they are less efficient than the vapour compression system, they are very light, low in cost, silent in operation, and are environmentally friendly. A thermoelectric module thus uses a pair of fixed junctions into which electrical energy is applied causing one junction to become cold while the other becomes hot. Because thermoelectric cooling is a form of solid-state refrigeration, it has the advantage of being compact and long lasting. It uses no moving parts except for some fans, employs no fluids, and do not require bulky piping and mechanical compressors used in vapour-cycle cooling systems. Such sturdiness favour thermoelectric cooling over conventional refrigeration in certain situations. The compact size and weight requirements, as well as portability in the design, rule out the use of conventional refrigeration.

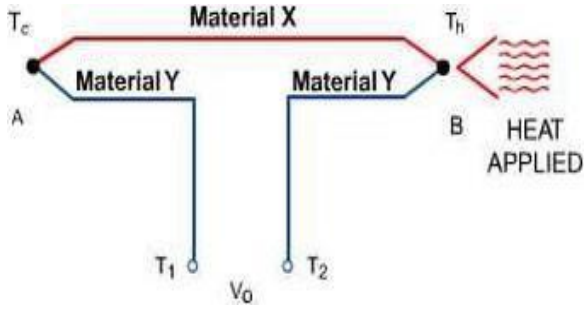

Fig. 1.1 Peltier effect

2. THERMOELECTRIC COOLING MODULES

Although Peltier effect was discovered more than 150 years ago, thermoelectric devices have only been applied commercially during recent decades. Lately, a dramatic increase in the application of TE solutions in optoelectronic devices has been observed, such as diode lasers, photo detectors, solid- state pumped lasers, charge-coupled devices (CCDs) and others. The thermoelectric module consists of thermocouple formed by pairs of P-type and N-type semi-conductor thermo element which are electrically connected in series configuration and thermally connected in parallel configuration. Due to their solid state construction the modules are considered to be highly reliable. For most application they will provide long, trouble free service. For cooling application, an electrical current supply is given to the module, heat is transferred from one side to the other, and the result is that the module will become cooler at one side and hotter at the other side.

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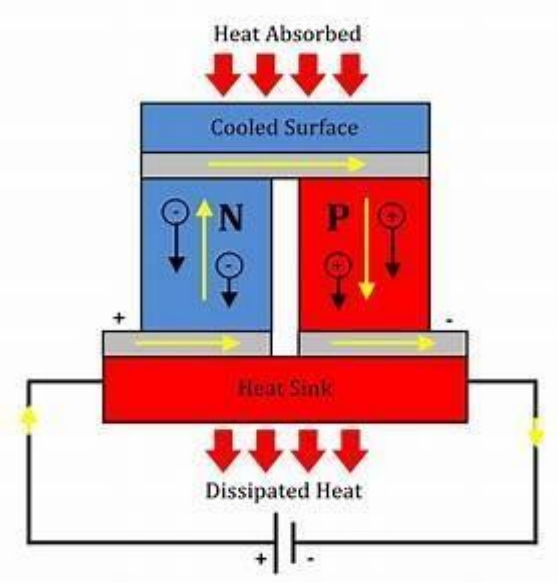

Fig. 2.2: Module working

Thermoelectric refrigerator works on the PELTIER effect that The peltier - see back effect, or thermoelectric effect , is the direct conversion of thermal differentials to electric voltage and vice versa. The Peltier-see back effect and Thomson effect are reversal of one another ,joule heating cannot be reversible under the laws of thermodynamics.

4 DESIGN OF THERMO ELECTRIC REFRIGERATOR

4.1 Project Objectives

In this proposed work, the main aim is to develop a refrigeration system with a capacity of 4L of cooling chamber. It is necessary to design a system capable of maintaining the temperature of the materials between 3 0C to 23 0C

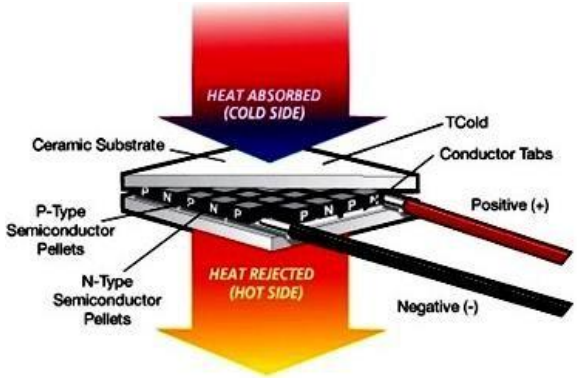

Fig. 2.3: Thermoelectric module

Thermoelectric cooling uses the Peltier effect to create a heat flux between the junction of two different types of material . A Peltier cooler , heater or thermoelectric heat pump is a solid-state active heat pump which transfer heat from one side of the device to the other, with consumption of electrical energy, depending on the direction of the current assembly

3 GEOMETRY

With the constraints imposed by the objectives a double walled rectangular box with an insulation sandwiched between the walls is selected and having the following dimensions
Top and bottom panel dimensions = 0.35 x 0.35m
Vertical side panel dimension = 0.35 x 0.35m Front and back panel dimensions = 0.35 x 0.35 m
4.3 Materials
Mild steel sheets with thermal conductivity of 52W/mK were used as outer wall. Expanded polystyrene (EPS) slabs with 5cm thickness having a density of 30kg/m3 and thermal conductivity of 0.33W/mK were used to give the required thermal insulation. Typical values range from 0.032 to 0.038 W/mK depending on the density of the EPS board. The value of 0.038 W/mK was obtained at 15 kg/m3 while the value of 0.032 W/mK was obtained at 40 kg/m3.

Design Procedure

In designing a thermoelectric cooling system, one of the most critical processes is to reach an understanding of the thermal load. With this vital information, we can able to choose the best TE device or heat exchangers for the job. Each of the thermoelectric cooling system has a unique capacity for moving heat. In order to achieve the performance objectives estimate of the amount of heat must be removed from the thermal load is calculated. Once the module is selected, thermosiphon system for heat dissipation from the hot side of the module is designed based on the amount of heat that has to be removed.

Heat load calculation

The two elements of thermal load in thermoelectric refrigeration systems include active and passive loads.
Active load is considered whenever part of the load actually produces heat. For example in an electronic circuit the circuitry would dissipate wattage depending upon its voltage and current requirements. Many TE applications don't have an active load and this term can be entirely discarded in these cases. To maintain a temperature difference between the thermal load of the system and the ambient environment, a small amount of energy must be continually moved into or out of the load. The rate at which this energy is moved is the passive load. With a TE system, the main aim is to keep the thermal load colder than the ambient temperature. But unfortunately, no matter how well the design of the system, there will be some leakage in the system. There is no insulation available with an infinite thermal resistance, so some heat will pass right through the primary line of defense. Furthermore, seals used to cope with the inevitable holes will also be imperfect. Thus, in a cooling application, some heat leakage into the thermal load will occur from the ambient environment.
Passive heat load: First we have to identify the greatest temperature difference between the thermal load and the

ambient environment that can occur. For cooling, what is the highest ambient temperature and how cold will the load need to be in that circumstance. This is generally the worst case. If we design the system so that we will have the required cooling capacity in that worst case, we will have more than enough potential for every other situation. The worst-case difference between the ambient and load temperatures will be the temperature difference, 'ΔT' in the equations which follow. Including both the conductive and convective heat transfer components of the load, we can use this equation: 1TAQLhkΔ=+

Temperature to be maintained inside the cabin = 10 0C
Outside temperature or ambient temperature = 30 0C
Temperature difference between the cabin walls = **30 – 10**
= 20 0C
KMS = 52 W/mK

Practiced commercially. Its advantages lies in its Ease, suppleness and its application in large scale Production and, in principle it permits conventional metal processing route to be used, and its little cost. The cost of preparing composites materials using a Casting method is about one-third to one-half that of other methods. Normally, stircasting of MMC Involve producing a melt of the chosen matrix Material, followed by the addition of a reinforcing material into the melt, and achieving a suitable dispersion through stirring. The subsequent step is the solidification of the melt containing suspended particles to obtain the desired distribution of the dispersed phase in the cast matrix. In the composites formed through this method, particle distribution will vary significantly depending on process parameters during both the melt and solidification stages of the process .The addition of particles to the melt drastically changes the viscosity of the melt, and this has outcomes for casting processes. It is vital that solidification occur before considerable settling has been allowed to take place. The process is generally attained out at two dissimilar ranges of temperature of the melt, beyond the liquids temperature or at the melt temperature controlled within the partially solid range of the alloy The technique concerning the latter range of temperature is called the compo-casting process and it is very efficient in making cast composites with elevated particle content. The most important condition when using a stir casting technique is continuous stirring of the melt with a motor driven agitator to prevent settling of particles.

5 FABRICATION AND ASSEMBLING

5.1.THERMOELECTRIC MODULE

Thermoelectric module (Peltier module) are solid-state heat pumps that operate on the Peltier effect. Heat pump is a thermoelectric system, which transfer heat from

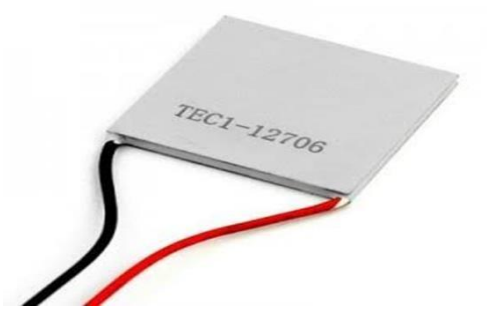

Fig no : 3

low temperature body and gives out the same to high temperature body.

5.2 Heat sink

The values obtained in the preceding analysis are used to assess overall system feasibility. We want **to** qualify our assumption of 15°C temperature rise across heat sink. The efficiency of the heat sink has a significant influence on the heat pumping capability of the thermoelectric module. The hot side of the module must interface with an efficient

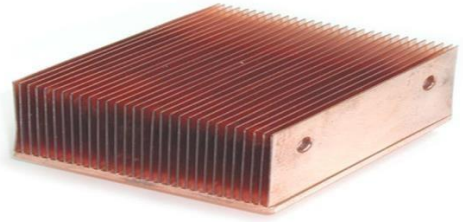

Fig No : 4

Fig. No :5

5.4 HEAT SINK FAN

Sometimes the heat sink itself become hot during the heat transfer to overcome this problem
a device called heat sink fan is used for the refrigeration area was reduced from 33.1 ˚C to 13.2
˚C in approximately 450min. Coefficient of performance of the refrigerator (COPR) was calculated. Water is used in place of vaccine for taking measurements and calculation. In these calculations, the properties of water are (density = 1 kg/L and CP = 4187 J/kg).V = 2.0 L.

Coefficient of performance of the refrigerator (COPR) was calculated, cooling RinQCOPW= Q = m CPΔ T

Mass of water, m = density x volume = 2 kg Total heat removed from the water = 166642.6
Cabin Walls- The rectangular double walled cabin is made using Mild steel sheets of 1mm thickness. The Designed dimension (35cm x 35cm x 35cm), of the cabin is obtained by performing suitable

5.3 TEMPERATURE INDICATOR

The temperature indicator is device that is used to know about the temperature inside the chamber of refrigerator .It has a probe which is inserted inside the chamber of refrigerator and the probe senses the temperature inside and give the temperature data to the output display.bending operations on the MS sheet. The sides are welded and riveted to give better surface finish. The top door panel of the cabin is fastened using spot welding .Rubber beading is given to prevent the heat leakage, through the sides of the top door panel. To prevent radiation heat transfer and to give better surface finish, the outside of the cabin is coated with black paint.

rfines the heat.

Fig No : 6

Fig No: 7

Insulation- EPS slabs with 50 mm thickness which is having a density of 30kg/m3 were used to obtain the required thermal insulation. For the selected

6 ERFORMANCE OF THE THERMOELECTRIC REFRIGERATOR

The active heat load is expressed as the equivalent cooling power that the unit will need to provide when the sample at ambient temperature is placed in the container. It was decided that two liter of water at room temperature took as the test sample .When the designed thermoelectric refrigerator was tested, it was found that the inner temperature of the expanded polystyrene foams the mechanical resistance varies from 0.4 to 1.1 kg/cm2. There are various grades of foams available with density

7 CONCLUSION

This is completely eco-friendly project multipurpose and portable. As the cooling un are of small size , silent contains no liquids or gases, have no moving parts and have a long life.The coefficient of performance of this refrigerator is much smaller than that of a conventional compressor -type refrigerator when the required cooling capacity is high
We have been successful in designing a system that fulfils the proposed goals. However we do realize the limitations of this system. The present design can be used only for light heat load to lower its temperature to a particular temperature. The system is unable to handle fluctuations in load. Extensive modifications need to be incorporated before it can be released for efficient field use.

8 REFERENCE

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