Industrial Engineering Journal
ISSN: 0970-2555
Volume : 51, Issue 12, December 2022

SWIFT WATER FREEZERS DESIGN AND CONSTRUCTION STUDY USING THERMOELECTRIC MODULES

S.M. Shafee, Dept of Mechanical Engineering, Sree Venkateswara College Of Engineering, Nellore (Dt), Andhra Pradesh, India.
M. Mercy Lydia, Dept of Mechanical Engineering, Sree Venkateswara College Of Engineering, Nellore (Dt), Andhra Pradesh, India.
V.Varun Kumar, Dept of Mechanical Engineering, Sree Venkateswara College Of Engineering, Nellore (Dt), Andhra Pradesh, India.
S. S. Ravishankar, Dept of Mechanical Engineering, Sree Venkateswara College Of Engineering, Nellore (Dt), Andhra Pradesh, India.

ABSTRACT
The employment of numerous approaches to produce a refrigeration effect using a thermoelectric module—which we now utilise to provide a cooling effect—has become feasible as a result of ongoing scientific and technological advancement. The major goal of its portable freezer is to generate a chilling impact that will help keep insulin under difficult circumstances. Since it relies on the Peltier effect, a portable thermoelectric module is used in its place of a compressor. With the use of the Peltier effect, effectiveness is preserved while also creating a hot and a cool side.
A thermoelectric cooler uses components that are readily available on the market and functions as a solid heat pump. Because of the different system mechanics, the thermoelectric refrigerator doesn't produce CFCs (cfc), is pollutant-free (contains no liquids or gases), portable, small, and makes no noise or vibration. It is a prototype and uses semiconductor materials to instantly cool or heat using the Peltier effect. It benefits from not having any moving components and being maintenance-free.

Keywords- Thermoelectric modules, SMPS, Heat sink, Fans, Submersible Pump**.**

1. INTRODUCTION
In typical cooling systems, such those found in refrigerators, heat is transferred using a compressor and a working fluid. Thermal energy is received and released as the working fluid expands and contracts, changing phases from liquid to vapour and back again. Semiconductors can use Peltier coolers, which employ thermoelectric cooling.
Compared to conventional procedures, there are several advantages. They are robust, long-lasting, and silent because they include no moving parts and only solid-state technology. They are a more environmentally friendly alternative to traditional refrigeration because they don't include any ozone-depleting chlorofluorocarbons. They are frequently substantially larger than equipment that uses a compressor.
However, they are less efficient than standard refrigerators. As a result, they are used in specialised applications, where their unique advantages make up for their low efficiency. Peltier coolers are often employed in situations where compact size is necessary and the cooling demands are not too significant, such as cooling electronic components, but certain large-scale uses (on submarines and surface ships) have been investigated. The Peltier effect is used in thermoelectric cooling to produce a heat flux at the junction of two different types of materials.
A Peltier cooler, heater, or thermoelectric heat pump uses electrical energy to move heat from one side of the device to the other, depending on the direction of the current. Other names for this technology include Peltier devices, solid state refrigerators, and thermoelectric coolers (TECs). Additionally, the phrase "thermoelectric battery" is frequently used. Although cooling is the most frequent application in practise, it can also be used to heat things up. It can also be used to heat or

cool a space as a temperature controller.

2. LITERATURE SURVEY

Ameya Dilip Khodegaonkar and Sudheer Madhav Patil et al (1)
The use of TEM for water freezing has been attempted. With the use of such TEMs, water may be frozen without the need of any refrigerant and impressively in just three minutes. This study discusses the creation of a quick icing device that uses the thermoelectric effect. In order to achieve speedy icing, the best TEM is chosen based on cooling capacity and current consumption. A 500ml cooling box is created to achieve icing in 1.5 minutes. According to the design outcomes, the quick icing machine needs 16 TEMs (TEC1-12706) and 4 copper heat sinks with 26 fins each.
Department of Mechanical Engineering, PVPIT, Bavdhan, Pune.Indianagesh Kudva, Veeresha rk and Muralidhara et al (2)
The concept of thermoelectric (TE) energy was developed as a result of the increased awareness of environmental degradation caused by the production, use, and discharge of chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) as heat carrier fluids in conventional refrigeration systems. This concept is unique because it allows for reversible energy conversion, such as from thermal to electrical and vice versa. All TE energy applications are built on the Seebeck and Peltier phenomena. Due to its ability to convert energy in both directions, thermoelectricity has a wide range of uses. Due to its eco-friendly features and unique advantages, TE devices have become more and more popular in recent years due to advancements in technology and concerns about global warming. Due to its straightforward design and operation, compact size, and need for a DC supply, thermoelectric energy has a wide variety of applications in many industries, including power production, refrigeration, air conditioning, specific heating/cooling, and biomedical equipment. This study article provides a comprehensive analysis of recent advancements and research on thermoelectric energy applications in fields including power production, refrigeration, electronic device cooling, and medical sector applications, among many others.

3. FABRICATION OF RAPID WATER FREEZER

Two separate semiconductors—one n-type and one p-type—are used because it is important for them to have differing electron densities. There is no need for a separate insulator because the electrically and thermally parallel alternating p & n-type semiconductor pillars are connected by thermally conducting plates on either side, which are frequently constructed of ceramic. When a voltage is applied to the free ends of the two semiconductors, a DC current flows across the junction between them, causing a change in temperature.
The cooling plate side of the device absorbs heat, which is then sent to the opposing side of the device via the semiconductor. The cooling capacity of the entire device is determined by the total cross section of all the pillars, which are typically electrically connected in series to reduce the necessary current to usable levels. The length of the pillars strikes a balance between longer pillars, which increase thermal resistance between the sides and allow for a lower temperature to be reached but lead to more resistive heating, and shorter pillars, which boost electrical efficiency but allow for more heat to transfer from the hot to cold side through thermal conduction.
For large temperature differences, longer pillars are far less efficient than stacking separate, progressively larger modules; the modules get largeras each layer must remove both the heat moved by the above layer.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 51, Issue 12, December 2022

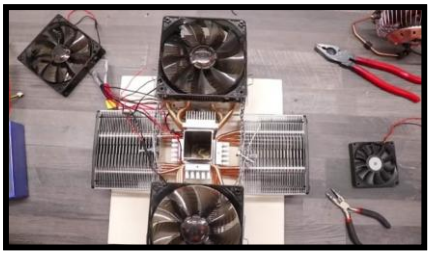


Fig.1 Top view of the Freezer

Fig.2 Side View of The Freezer

Methodology
Peltier modules

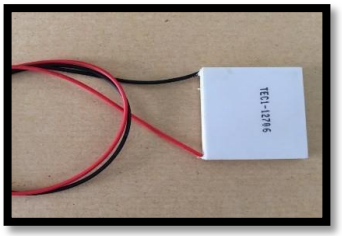


Fig.3 Peltier Module

Solid-state heat pumps known as thermoelectric modules (or Peltier modules) rely on the Peltier effect to function. A heat pump is a thermodynamic device that distributes heat from a low-temperature body to a high-temperature one.

Heat sink

Fig.4 Heat Sink

The heat produced by an electrical or mechanical equipment is transferred into a cooling fluid in motion via a passive heat exchanger called a heat sink. Since the fluid is moving as a result of the heat transfer, the device temperature can be regulated to levels that are physically possible.

Heat sink fan

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 51, Issue 12, December 2022

Fig.5 Heat sink Fan

In order to solve this issue, a device known as a heat sink fan is utilised to remove induced heat from the heat sink's fins. This can happen when the heat sink itself gets hot during the heat transfer. Thus, by placing these fans over the heat sink's fins, the heat generated there is cooled.

Submersible Pump

Fig.6 Pump

Submersible pumps are positioned inside the water reservoir that has to be drained. As a result, they are frequently employed for pond emptying, wastewater pumping, drainage during floods, and even as pond filters. Submersible pumps include the filtration units that are used in fish aquariums.

Water Block

Fig.7 Water Block

The best way to remove heat is via water blocks, often called liquid cold plates. They frequently outperform a typical air-cooled heat sink and fan by a factor of 4–5. The idea is straightforward: you supply a source of cold liquid to the water block's intake (usually water, ethylene glycol/water, or Fluorinert). The liquid moves back and forth through the water block's numerous chambers, soaking up heat generated by the TECs or power electronics. After then, the warmer liquid leaves the water block.

Sump

Fig.8 Sump

In a sump, a pump is used to circulate coolant inside a cuboidal-shaped water container. The sump's

size that was used in this project.

The sump acts as the peltier cooler's foundation, on which the evaporator is installed. The heatsink that is fastened above the peltier that is attached to the bottom side of the evaporator is immersed in the sump's water.

Thermocol Box

Fig.9 Thermocol Box

Due to its poor thermal conductivity, thermocol boxes prevent heat from the environment from entering the box where ice cubes are stored through their walls. As a result, ice cubes kept in thermocol boxes last a very long period in their solid condition. Insulation is provided via thermocol boxes.

PLASTIC TUBE

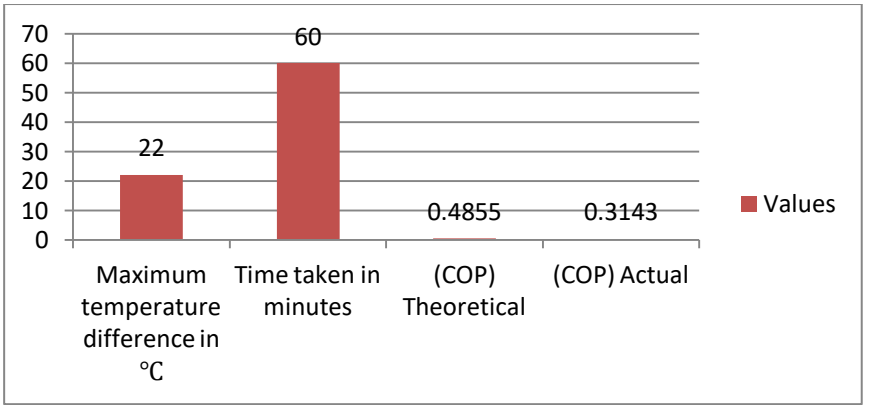
Fig.10 Plastic Tube

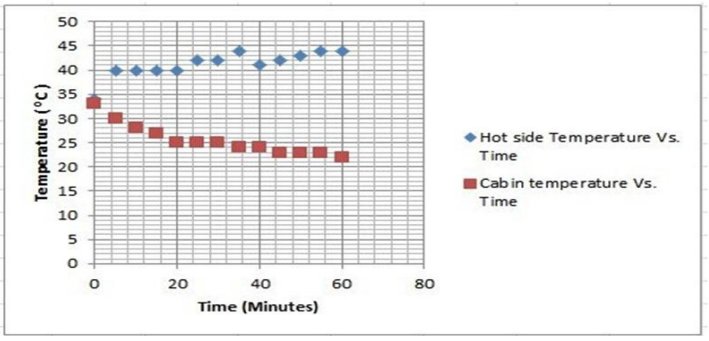
The peltier device, located on the top side of the evaporator box, is fed water from the sump via a plastic tube. The water pump is linked to one end of the tube, and the peltier is connected to the other end. In pneumatic, hydraulic, industrial, medicinal, and many other applications, plastic tube is frequently utilised as flow lines for fluids and gases because it is lightweight and adaptable.

Applications

Electronic
Medical
Aerospace
Telecommunications

4. Results and Discussion





It is clear from the results table and graphs that as time passes, the temperature within the cabin gradually decreases. At the same time, the temperature on the hot side stays consistent (at close to 41oC).

CONCLUSION

Using a test base in AS, it has been found that the thermoelectric freezer offers quick icing. Ice may be made from 500ml of water in 15 minutes. It is also possible to create a thermoelectric freezer with a changeable size for the required volume of water when working with vast volumes of water. The main problem is the thermoelectric freezer's Coefficient of Performance in its intended form. A thermoelectric freezer has a very low Coefficient of Performance (COP) (0.78 as opposed to 3.32 for a convection refrigerator). This restricts the use of thermoelectric freezers nowadays.Unlike a typical refrigeration system, which has many pricey and loud parts including compressors, condensers, and evaporators. Despite the fact that they are more affordable and environmentally benign, the above-mentioned components and risky refrigerants like freon 12, R-134A, and R-32 are not used in thermoelectric freezers.

REFERENCES

1. Aste, N., Del Pero, C., & Leonforte, F. (2017). Active refrigeration technologies for food preservation in humanitarian context – A review. Sustainable Energy Technologies and Assessments, 22, 150– 160. https://doi.org/10.1016/j.seta.2017.02.014.
2. Chill Challenge—Engineers Without Borders USA. (n.d.). Retrieved October 29, 2019, from https://www.ewb-usa.org/chill-challenge/
3. Dai, Y. J., Wang, R. Z., & Ni, L. (2003). Experimental investigation and analysis on a thermoelectric refrigerator driven by solar cells. Solar Energy Materials and Solar Cells, 77(4), 377–391. https://doi.org/10.1016/S0927-0248(02)00357-4.
4. Field, R. L. (1980). Photovoltaic/Thermoelectric refrigerator for medicine storage for developing countries. Solar Energy, 25(5), 445–447. https://doi.org/10.1016/0038-092X(80)90452-1.
5. Portable medicine cooler designed by TECA inside a Pelican box. (2016, July 29). Thermoelectric. https://www.thermoelectric.com/portablemedicine-cooler/
6. Rademann, K., Raghuwanshi, V. S., & Hoell, A. (2016). Chapter 3 - Crystallization and Growth Mechanisms of Nanostructures in Silicate Glass: From Complete Characterization Toward Applications. In B. Karmakar, K. Rademann, & A. L. Stepanov (Eds.), Glass Nanocomposites (pp. 89–114). William Andrew Publishing. https://doi.org/10.1016/B978-0-323-39309- 6.00003-1.
7. Terasak.I (2016). Thermal Conductivity and Thermoelectric Power of Semiconductors. In Reference Module in Materials Science and Materials Engineering. Elsevier. https://doi.org/10.1016/B978-0-12-803581- 8.00771-2.