JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Low-Cost Medicine Storage Unit using Semi-conductor Thermoelectric Peltier Device

M. Kamakshi Kanchana, Assistant Professor, JNAFAU, Hyderabad, India

Abstract— Only 33% households possess refrigerator in India. Many places in India experience summer day time temperatures between 37-47 degrees Celsius. The recommended storage temperatures for most of the medicines is around 25 degrees Celsius and vaccines and insulin have much lower storage requirements. Life-saving medicines getting spoilt or losing efficacy due to severe heat indoors can pose a grave threat to elderly and sick people who are dependent on medication. This paper proposes a very low-cost medicine storage device based on Semiconductor Peltier device. When there is no requirement to store medicines, it can be configured to work as a personal cooling fan to give relief against heat in small rooms. Peltier Effect was discovered in 1934, however commercial applications started in the last two decades after the availability of low-cost semiconductor-based Peltier devices. Peltier devices are extensively used in cooling computer microprocessor integrated circuits, space suits and automobiles. Portable DC refrigerators are available in the market. They are expensive and designed mostly for cooling beverages for camping enthusiasts. This paper proposes a low-cost Medicine storage box cum personal cooler based on currently available Semiconductor Peltier device and other electric components. Prototype is built and results are reported. Detailed design instructions are given so that it can be assembled by semi-skilled electricians and provide it as an essential household equipment. As it operates on 12 Volts, DC as well as 240 V 50 HZ supply, it can operate on any car battery or UPS back-up battery. For households that already have a refrigerator, it can work as a back-up device during natural calamities with electric power disruption and during travel. Interior designers can incorporate this device as an essential utility and make it part of modular kitchens and storage units.

Keywords— Medicine storage Unit, Thermoelectric Refrigerator, Semiconductor Peltier Device, Medicine Storage Temperature, Medicine Storage during natural disasters

1 INTRODUCTION

The penetration of refrigerators in India is just 33%. A typical household with four members requires 165 liters capacity refrigerator costing around Rs7000 (Statista, 2020). On an average, monthly energy bills exceed Rs.400/. The following blog explains the computation of energy requirement for the refrigerator (E4U, 2017-2022). Initial cost and monthly running expenditure are few deterrents for the household to own a refrigerator. Furthermore, for households, with less than 100-Watt sanctioned load, power tariffs are highly subsidized and tariffs increase exponentially with more sanctioned load. In most cases sanctioned load is sufficient to run couple of bulbs and fans. Households are reluctant to opt for increased sanctioned loads. A 165-liter refrigerator rated 150-Watt power will not be a viable for such households. The proposed low-cost device is around 60 watts rating is a viable option (Retail Supply Tariff Order FY 2019-20, 2019-20).

While Food preservation, reduced food wastage and consumption of modern life style comforts like ice creams, deserts, cold beverages is the main motivation for owning a refrigerator. It also has a vital functionality to store lifesaving medicines during harsh summers where the temperatures rise above 45 degrees Celsius in many regions in India. The recommended temperature to store medicines is around 25 °C. Medicines lose their efficacy if stored if exposed to higher temperatures. When lifesaving medications and injection vials losing their potency pose great risk to sick and elderly if they are dependent on such medications (STOLLER-CONRAD, 2012). Furthermore, in households that have refrigerators, during natural disasters, adverse climate conditions like cyclones, floods non availability of electricity for several days can lead to similar situation. Extensive research has been done and recommendations are made to deal with medicine storage during natural disasters and how to handle them after the disaster (How to take medicines safely in a natural disaster (bushfire, floods, cyclones), 2022) (Safe Drug Use After a Natural Disaster, 2019) (Impact of Severe Weather Conditions on Biological Products, 2018).

Low-cost medicine storage device addresses this serious problem effectively and this paper proposes a simple design based on Semiconductor Thermoelectric Peltier device. Prototype is built and experimental results are presented. Very simple design drawings

and bill of material is given so that it can be easily assembled by semi-skilled electricians.
Rural India mechanics are well known for their ingenuity and frugal engineering innovation popularly known as 'Juggad' (Jugaad, 2022). This paper attempts at frugal engineering innovation with limited resources to solve a critical problem to store medicines during harsh summers. Detailed design and bill of material is provided to encourage rural technicians to build this essential device.

1.1 THERMOELECTRIC EFFECT

Thermocouple is a device consisting of two dissimilar conducting material forming an electric junction. When one of the dissimilar conducting material is at a different temperature, thermocouple develops an electric voltage. Conversely, when electric current is passed through dissimilar conducting material, it creates a temperature difference between dissimilar conducting material.
Thermoelectric effect is due to three independently discovered effects. Seebeck Effect (discovered by Thomas J Seebeck 1821) deals with the phenomenon of EMF between dissimilar metal junctions when there is a temperature difference between dissimilar metals. Peltier effect (discovered by Jean Charles Athanase Peltier,1834) deals with the converse phenomenon that when electric current is passed through dissimilar metal junctions, there will be a temperature gradient caused by heating or cooling of dissimilar metals. The third Thermoelectric effect was discovered by Lord Kelvin (William Thomson) in 1851. In different materials, the Seebeck coefficient is not constant with temperature, and if a spatial gradient in temperature will lead to a gradient in the Seebeck coefficient. If a current is driven through this gradient, then a continuous Peltier effect will occur (Thermocouple, 2022) (Thermoelectric effect, 2022).

Hundred years after the discovery, breakthrough in the production of semiconductor Peltier devices has attracted the industry for commercial use. Today Peltier devices are extensively used to cool integrated circuit chips on motherboards of electronic equipment (McKenzie, 2012). Space industry and automobile extensively uses semiconductor Peltier devices for heating and cooling. The current industrial applications of semiconductor Peltier device are given below. The list is not exhaustive and more and more innovative solutions are being proposed.

- Artificial satellites and space probes
- Microprocessor CPU cooling
- Laser diode-based equipment temperature stabilization
- Temperature regulated flight suits
- Air conditioning in submarines
- Portable DC refrigerators
- Beverage heating and cooling units for camping and other outdoor situations
- Automotive seat cooling/heating (Thermoelectric Cooling, 2022)

The device has two sides. A 12 V DC power source is connected to the device terminals. DC electric current flows through the device, one side of the device becomes hot and other side cold. A heat sink and fan are attached to the hot side and cold side pushed into thermally insulated box to create a cool chamber.

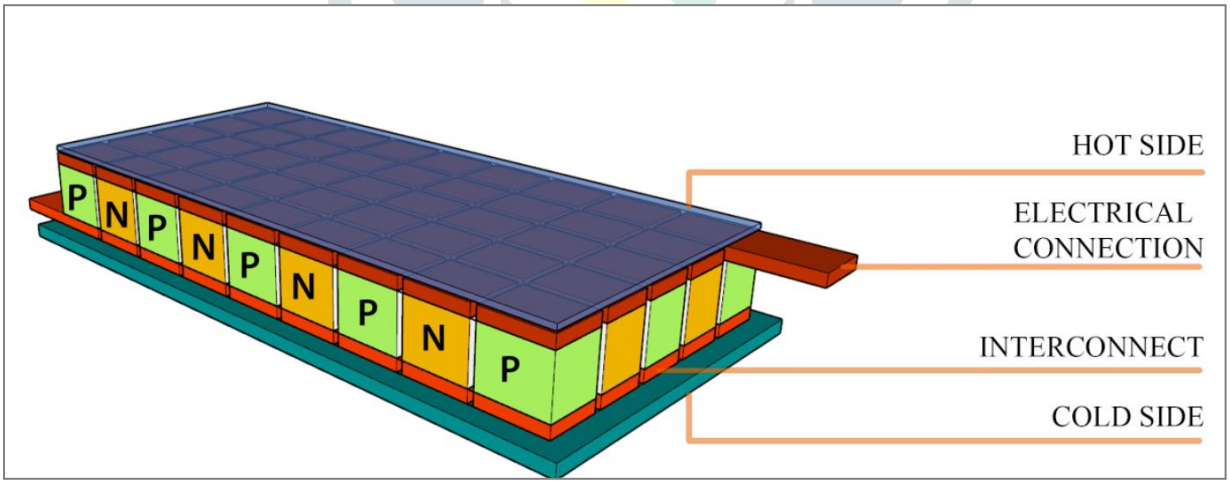

Figure 1 Peltier effect schematic diagram (Thermoelectric Cooling, 2022)

2.1 PRELIMINARY EXPERIMENTS

The following experiments are made using conventional bi-metal junction and semiconductor Peltier device to compare the operating parameters and understand Seebeck effect.

On a 50 mm mild steel screw SWG 15(1.829 mm outer diameter) wire around 12 turns are wound and wire ends are twisted and two ends of the copper wire are connected to a digital multimeter in mV range. Similarly, a semiconductor Peltier device TEC1-12705 Thermoelectric 5A Peltier Cooler Module.

Two sets of reading are taken one at room temperature and other with hot air blown on bimetal junction and hot side of Peltier device. (In the current device TEC1-12706, the side where component number printed is cold side and other plain side without any markings is hot side).

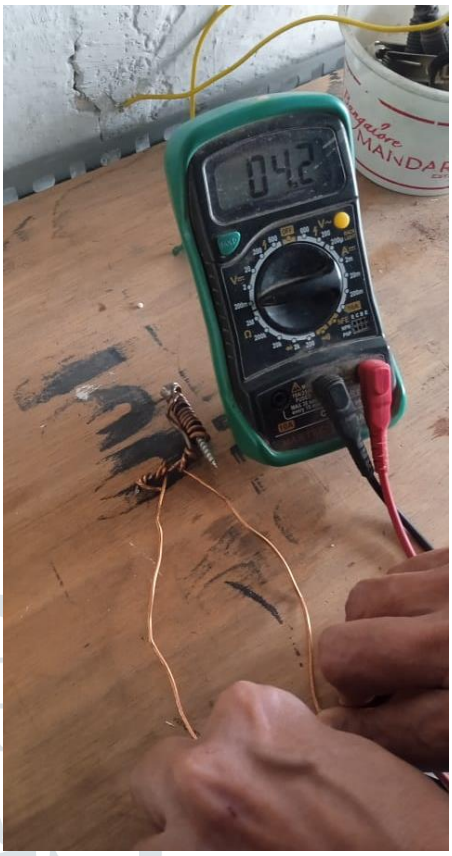

Figure 2 Voltage readings being tabulated

Voltage readings are tabulated below:

DESCRIPTION	*MV READING NORMAL TEMPERATURE*	*MV READING WHEN HOT AIR IS BLOWN*
BI-METALLIC JUNCTION	1.5	10.5
PELTIER DEVICE	189	935

Table 1 Voltage Readings

Semiconductor Peltier device exhibits very strong thermoelectric effect and because of this reason in recent years it has become the choice to build cooling units on computer mother boards to cool CPU IC chips, in space suits and automobiles. Due to mass production the device is available for Rs 200.

3.0 PROTOTYPES LOW-COST THERMOELECTRIC COOL MEDICINE STORAGE BOX CUM PERSONAL COOLER

In this paper detailed drawings and images of two prototype one for desktop use and other very compact unit for travel are presented. For the desktop unit, for personal cooling configuration, a 4-inch standard 100 CFM, 220V mains operated fan is used and it can be used as a room cooler too. For the compact unit, 4-inch, 12 V DC, 80 CFM fan is used and in the personal cooler configuration, it can cool small areas.

Peltier Device is assembled with standard parts available in the market. Two heatsinks, a smaller one for the cold side of the device and larger one for the hot side of the device are used. A small fan is used on the hotter side to expel the heat generated on the hot side of the device. The assembly of the device is detailed below.

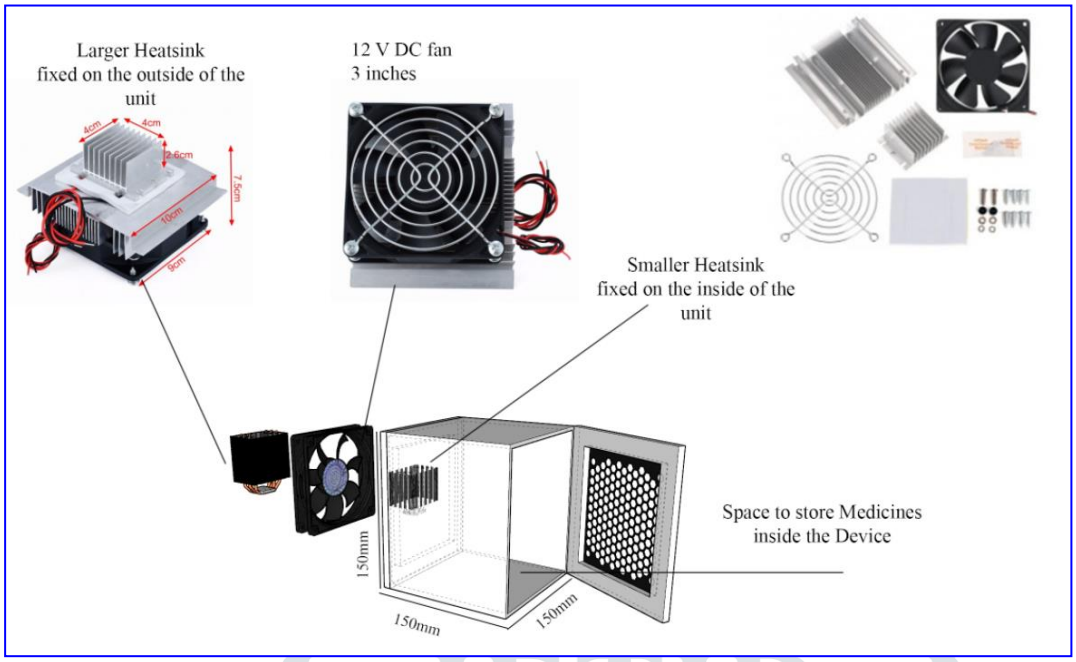

Figure 3 Concept design of the Peltier Desktop device

3.1 STEP BY STEP ASSEMBLY INSTRUCTIONS

- Take the large heatsink on the smoother side (opposite to side with fins) apply heatsink compound
- Place the unmarked side of Peltier device TEC1-12705 firmly on the place where heatsink compound is applied
- Around the Peltier device, place the insulation sticker. The adhesive of the insulator should be pressed on the heatsink for proper contact
- Apply heatsink compound on the marked side of the Peltier device
- Place the smoother side of smaller heatsink (opposite to side with fins) on the Peltier device marked side
- Use the screws and thermal spacer to fasten both the heatsinks
- Fix the small (3 inch) 12 V DC fan (opposite to side with fins) ion the bigger heatsink. Ensure that air flow direction is away from the heatsink. This fan is needed to expel heat from the bigger heatsink
- Connect the fan terminal wires and Peltier Device terminal wires (Red to positive and Black to negative) in parallel to 12 V DC power supply or 12 V battery (35 AH Car Battery)

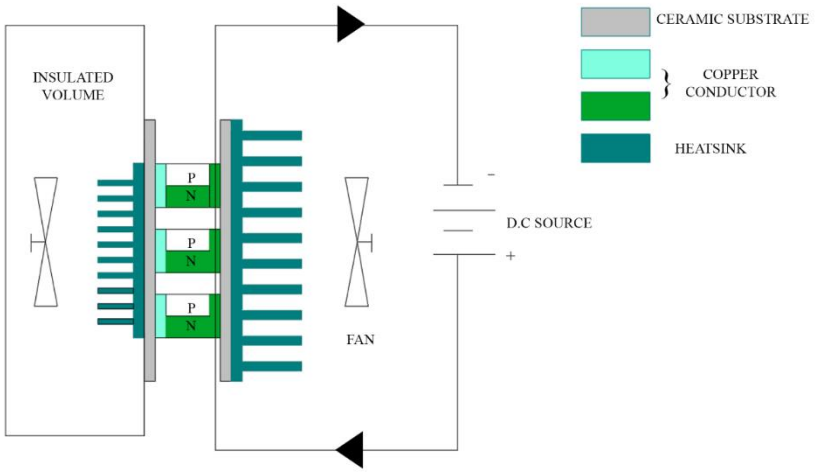

Figure 4 Circuit Diagram

3.3 ENCLOSURE DESIGN DETAILS

For the desktop unit, a wooden box with 230X230X230 milli meter internal dimensions is built. For the compact portable unit 150X150X150 mm dimensions is built. Both units are built using commercial plywood. The front side of the unit is designed with hinges and a fan is fixed to convert the unit as a personal cooler. Medicines can be stored inside the chamber.

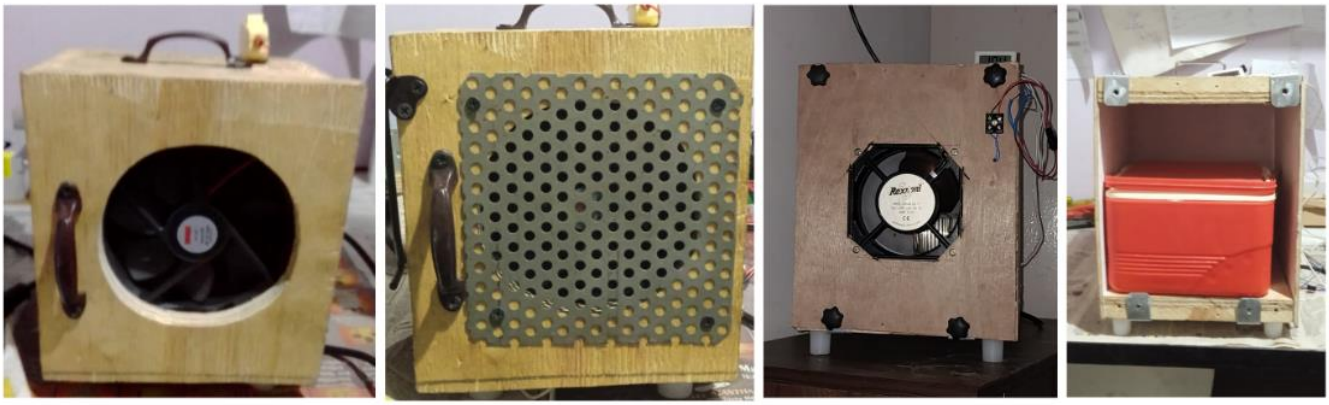

Figure 5 150x150x150 mm Size Peltier as a Cooling Device for Medicine Storage

A vial storage box 75 mm X 75mm X 75 mm is also designed which snug fits into the cabinet. This is an ideal accessory to store injection vials which require lower temperature,

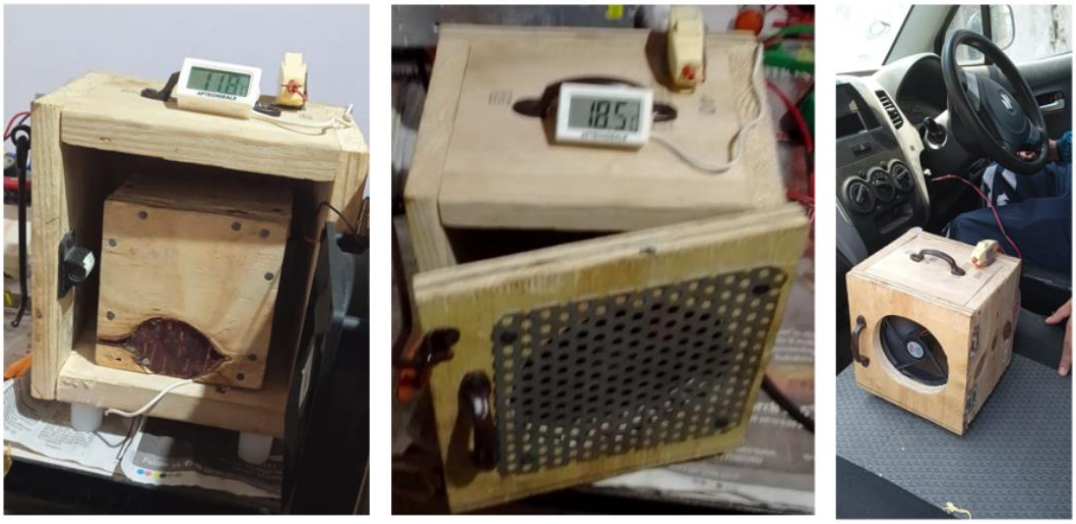

Figure 6 Storage Provision for Medicines given inside the unit

3.4 BILL OF MATERIAL AND INDICATIVE COSTS

The following table give the bill of material and indicative price (as on March 22)

DESCRIPTION	INDICATIVE PRICE
SEMICONDUCTOR PELTIER DEVICE TEC1-12075	200
HEATSINK KIT WITH SMALL FAN FOR HOT SIDE	475
WOODEN CABINET, FASTENERS AND WIRES	300
12V /10 AMPERES SMPS POWER SUPPLY	550
TOTAL	1525

Table 2 Bill of Material Costs

4 EXPERIMENTAL RESULTS

Within 10 minutes after switching on the power, the unit has reached steady state temperature of 11.8 degrees Celsius and within 30 minutes the vial storage box that fits into the cabinet achieved steady state temperature of 10.2 Degrees Celsius degrees which is an ideal temperature to store injectable vials. For ordinary medicines, with 25 Degrees Celsius as recommended storage temperature, the entire cabinet can be used and withing few minutes after switching the power supply, the temperature inside the cabinet was around 18.5 Degrees Celsius. Portable device operated inside a car using car battery supply.

In the personal cooler configuration, the device could deliver air around 22 Degrees Celsius providing comfort to people in the vicinity. The compact unit performed equally well indoors and inside a car when run on car battery. This makes the unit versatile offering best utility during travel and under extreme weather conditions and natural calamities where there is electric power disruption for several days.

5. CONCLUSION

Low-Cost Thermoelectric Cool Medicine Storage Box Cum Personal Cooler Using a Semiconductor Peltier Device can be easily assembled by any semi-skilled electrician with readily available components. The prototypes have demonstrated the functional utility of the concept. The detailed instructions and images provided in this paper can be effectively used to replicate and build similar units. These units can go long way in mitigating the risk of live saving medicines losing their efficacy in lower income households that do no not have refrigerator. Furthermore, it can be used as a lifesaving equipment during natural calamities where it is common to have long electric power disruptions.

REFERENCES

E4U. (2017-2022). *Refrigerator Power Consumption, Calculation, Power Saving Tips*. Retrieved from Electrical4U Website: https://www.electrical4u.net/energy-calculation/refrigerator-power-consumption-calculation-power-saving-tips/#:~:text=In%20our%20case%2C,)%20%2F1000%20%3D%201.17%20kWh

How to take medicines safely in a natural disaster (bushfire, floods, cyclones). (2022, March 1). Retrieved from Health Direct Website: https://www.healthdirect.gov.au/blog/how-to-take-medicines-safely-in-a-natural-disaster

Impact of Severe Weather Conditions on Biological Products. (2018, August 23). Retrieved from U.S Food & Drug Administration website: https://www.fda.gov/vaccines-blood-biologics/safety-availability-biologics/impact-severe-weather-conditions-biological-products

Jugaad. (2022). Retrieved from Wikipedia website: https://en.wikipedia.org/wiki/Jugaad

McKenzie, J. (2012, August 10). *The Peltier Effect*. Retrieved from Slide Share Website: https://www.slideserve.com/morse/the-peltier-effect

(2019-20). *Retail Supply Tariff Order FY 2019-20.* Madhya Pradesh: Madhya Pradesh Electricity Regulatory Commission.

Safe Drug Use After a Natural Disaster. (2019, August 28). Retrieved from U.S Food & Drug Administration website: https://www.fda.gov/drugs/emergency-preparedness-drugs/safe-drug-use-after-natural-disaster

Statista. (2020, July). *Household penetration rate of home appliances in India in 2018*. Retrieved from Statista Website: https://www.statista.com/statistics/370635/household-penetration-home-appliances-india/#:~:text=This%20statistic%20shows%20the%20household,33%20percent%20had%20a%20refrigerator

STOLLER-CONRAD, J. (2012, July 11). *Why You Should Keep Medicines Out Of Summer Heat*. Retrieved from NPR website: https://www.npr.org/sections/health-shots/2012/07/10/156575072/why-you-should-keep-medicines-out-of-summer-heat

Thermocouple. (2022, April 18). Retrieved from Wikipedia website: https://en.wikipedia.org/wiki/Thermocouple

Thermoelectric Cooling. (2022, April). Retrieved from Wikipedia Website: https://en.wikipedia.org/wiki/Thermoelectric_cooling

Thermoelectric effect. (2022, May 22). Retrieved from Wikipedia website: https://en.wikipedia.org/wiki/Thermoelectric_effect#:~:text=The%20thermoelectric%20effect%20is%20the,different%20temperature%20on%20each%20side