ISSN: 0974-5823 Vol. 7 No. 1 January, 2022

International Journal of Mechanical Engineering

PELTIER MODULE BASED AIR CONDITIONER USING SOLAR ENERGY SYSTEM

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ABSTRACT

The primary focus of our study is on developing an air conditioning system that is both renewable and environmentally beneficial. Everything on this system is powered by direct current (dc). The main and secondary sections are separated by a comma. The cooling system is the main component, while heat dissipation is recycled as a secondary component. The peltier module, which is the system's beating heart, is the most critical component. The solar panel that provides the power is a pure dc source. The peltier module utilizes the peltier effect as its guiding concept. This reverse seebeck effect is caused by the voltage difference applied to the module. A dc fan is used to disperse the heat. In other words, cold air cools while hot air from the opposite side is utilised for a variety of household purposes like water heating or may be turned into energy. This is how refrigeration works. Using a thermoelectric module and the Peltier principle, the primary goal of this article is to research and evaluate a solar air conditioning system. This eco-friendly device uses renewable energy sources and is ideal for individuals living in rural areas without access to power.

Keywords: Peltier Module, Heat Sink, DC Fan, solar energy.

I. INTRODUCTION

Air conditioners are now commonplace in businesses and homes alike. However, for those living below the poverty line, it remains a pipe dream. Demands for refrigeration, air conditioning, food preservation and vaccine storage have increased globally, leading to more electricity being produced and consequently more carbon dioxide being released globally. This leads to an increase in global temperature, which is known as global warming or climate change. The peltier effect air conditioner, which is less expensive and does not need any electricity since it utilizes renewable energy, alters this situation. As an alternative, you may use peltier-based air conditioning, which turns waste heat into cooling. Developing nations need energy-efficient refrigeration that has a long service life and requires little maintenance. In a traditional cooling system, heat is transferred using a compressor and a working fluid. There are many benefits to using a peltier base air conditioner over a traditional one. Because they have no moving components, solid-state devices are more dependable, quieter, and more robust. Because they don't utilize ozone-depleting chlorofluorocarbon, this kind of air conditioning is safe for the environment. The traditional air conditioning system is much larger in comparison to this one. Peltier modules are already utilized in a wide range of tiny applications, but this study predicts that they will become more prevalent in big ones.

Due to the improvement in human living standards brought on by global industrialization, energy consumption is rising at an increasing rate. Energy demand is increasing at an alarming pace due to this, and so are restricted fossil resources like coal, petroleum, and natural gas. To combat pollution, global warming, and ozone depletion, researchers have focused on free energy sources such as solar, wind, hydro, and geothermal.

It is the most plentiful and cleanest kind of energy accessible for power production, and it is free to use. Solar

energy is derived from the sun's rays and may be used as thermal or electrical energy depending on how it is converted. Factories, businesses, etc. need a lot of power to operate their machinery, equipment, lighting, air conditioning, and refrigeration systems. The energy released by the sun on Earth in an hour is far greater than the total energy used by the whole world's population in a year. Solar energy is abundant during peak hours, so making good use of it may help meet future energy demands while also providing a clean, renewable source of power. Installing solar panels is expensive, but researchers are making progress in this field to improve system efficiency while also reducing the cost. To encourage participation, the government offers economic incentives, subsidies, and other forms of assistance.

These days, a functioning air conditioning system is a must. Air conditioning mass manufacturing is increasing, and that's what's behind the rising costs and increased energy usage. On the other hand, according to the United Nations Environment Programme, the building consumes 40% of all energy and emits 36% of all CO2 (UNEP). As a result, we've developed a solar air conditioner peltier module that improves cooling. The solar panel in this method collects solar thermal energy and utilizes it to power the system. As a result, heated air is utilized to condition indoor air. Electricity will be replaced in high usage by this method.

II. LITERATURE REVIEW

The authors of this paper are periyasamy r, hariharan k, naveen (2021), The rise in land temperature is a major problem across the globe, with the surge being twice as much as the worldwide average, according to one source. It's difficult to control the weather or nature outside of a four-wall structure, but doing it inside one is doable. As we all know, air conditioners work by transferring heat naturally and scientifically. Climate change has increased demand for comfort in recent years. As a result, air conditioner use and productivity rise, resulting in higher energy and financial costs. Solar energy must be used for the air conditioning system's electricity in order to avoid these kinds of situations from occurring. The AC system, which regulates and maintains the temperature of a conditioned space, is powered by solar energy. Air conditioning has become a requirement in recent years if we are to be comfortable in our living spaces. The emphasis of this article is thus on improving cooling on a DC air conditioning system with a peltier module incorporated. It is possible to operate our air conditioning system off of a solar panel, which stores charge in a battery. Due to the fact that it's renewable and ecologically beneficial, this will lower the cost for everyone.

Rahul and Dr. J. P. Kesari are Rohan Chandra's coworkers (2020), When you use a traditional air conditioner, you're depleting the ozone layer and polluting the environment. CFCs and HFCs are the most frequently utilised refrigerants. Although HFCs have less of an impact on the ozone layer than CFCs do, they are nonetheless contributing to the thinning of the ozone layer. Making the whole system eco-friendly would take a long time. In addition, additional issues such as increased power consumption, upkeep, servicing, and so on contribute to the search for a replacement to the current cooling system. These benefits may be addressed with a Thermoelectric Hybrid air conditioning system. The thermoelectric module is driven mostly by solar electricity, which is a free resource. The thermoelectric module receives electrical energy from the solar panel, which is subsequently converted back to solar energy. If solar energy isn't enough, the battery may be charged using electrical energy. Due to the Peltier effect, a temperature differential develops when the thermoelectric module receives electric current. By reversing the polarity, hot air may be pumped throughout the conditioned area using blowers that remove heat from the cold side. This is essentially a year-round air conditioner that may be used to a variety of uses.

As it is Freon-free and has no mechanical components, a photovoltaic thermoelectric air conditioning (PT A/C) system may be a better choice than a traditional air conditioning system. Under tropical climatic circumstances, this research examined the cooling and dehumidification capabilities of a solar-powered portable air conditioner (PT A/C). The system uses nine thermoelectric components to cool a 3.6 m3 test chamber. According to the findings of the study, input current had the greatest impact on cooling capacity and moisture removal rate, with an optimal current level of 5 A giving an average cooling capacity of 181 W and a moisture removal rate of 0.14 ltr/hour under the specified ambient circumstances. Indoor temperatures in the test chamber were 4 degrees cooler than in the unconditioned chamber, and 7.7 degrees cooler than in the surrounding air during operation. The interior relative humidity, on the other hand, ranges from 58 to 83

percent. For a 12 hour operation, the system uses 1.45kWh of energy and delivers a temperature between 23.8 and 27.8 oC at a current of 5 A.

This study was carried out by Diwania, S.Agrawal, et al (2020), Solar thermal and PV applications have received a great deal of attention in the last several decades due to the benefits of photovoltaic–thermal systems. As a result, the research in absorber design modification, development, and application will be presented in this article. According to prior research, the thermal energy produced by the PV module may be put to use in a variety of ways, which improves efficiency. These include air collectors, water collectors, and hybrid systems that integrate a heat pump with a solar thermal collector.

The work of G. An and colleagues has been published in the journal Science Translational Medicine (STM) (2019), Electric cars' air conditioning systems use a significant amount of the vehicle's onboard batteries' energy and have a significant impact on how far the vehicle can go. EV sorption type AC has been shown to reduce this portion of energy usage theoretically. In contrast, choosing optimum working groups based on local circumstances is not taken into account previously, which may result in both high efficiency and long-term consistency and dependability. The diverse solid sorption working pairs utilised in sorption type AC are thus investigated in this study under various temperature zones, Study of different working pairs (halide-ammonia) using Rubotherm balancing test unit was carried out, and candidate working pairs were chosen using Clapeyron equation and energy analysis. There is no other option for cold temperate zone (CTZ) except MnCl2; for warm temperate zone (WTZ), CaCl2 is preferred over combined double halide (MnCl2 and CaCl2).

III. PELTIER EFFECT

Thermoelectric effect is a direct conversion of temperature changes into electricity or viceversa. There are three effects based on thermoelectric principle. They are

- Seebeck effect
- Peltier effect
- Thomson effect

For this experiment, we're making advantage of the peltier effect. The Peltier effect is the process of transferring electricity via a conductor to produce a temperature differential. The TEC1-12706 peltier module is used here. The peltier effect is shown graphically below. When a semiconductor material, such as bismuth or telluride, is given a potential difference, a temperature differential is created when heat is absorbed from one end and dissipated on the other. There are two types of semiconductor material: n-type and p-type, and the electron and hole concentrations are at their highest in each of these. The electron in the n-type (where electrons make up the majority of charge carriers) travels in the opposite direction of the current, whereas the holes in the p-type (where holes make up the majority of charge carriers) move in the same direction as the current. As a result, the peltier effect may now be understood.

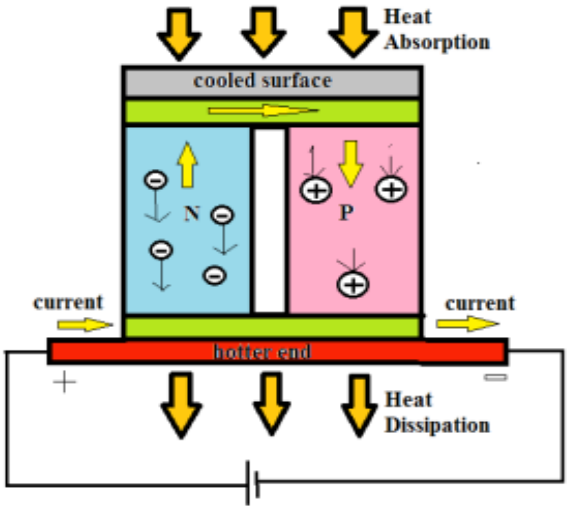

Figure 1: Peltier Effect

Components Required:

The main components required for making a solar based air conditioner are

- Peltier module
- Heat sink
- DC fan
- Solar panel
- Inverter
- Transformer
- Bridge rectifier
- Igloo box

Peltier Module:

The peltier module used here is TEC1-12706 which can give a temperature difference of nearly 40 degree celcius. The peltier module is made of 127 thermocouple. The size of the module is 40*40 mm. This single stage module is made of some selected high performance superior cooling material which can give a temperature difference of maximum 60°C.

Figure 2: Peltier Module

The main features of peltier module are listed below;

- High effective cooling and efficiency.
- No moving parts, no noise, and solid-state.
- Compact structure, small in size, light in weight.
- Environmental friendly, Ro HS compliant.
- Precise temperature control.
- Exceptionally reliable in quality, high performance.

The applications of peltier module are also listed below;

- Food and beverage service refrigerator
- Photonic and medical systems
- Temperature stabilizer
- Liquid cooling
- Portable cooler box for cars

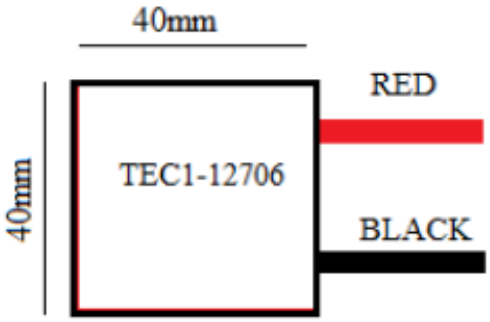

Figure 3: Description of Module

Heat Sink:

When electronics generate heat, the heat must be dissipated somewhere. Central processing units and graphics processors in computers are kept cool by heat sinks. It's also utilised for cooling in a lot of power electronics. Metals often used as heat sinks include copper and aluminium. The heat conductivity of copper is very high. Although aluminium is a superior heat sink material, it is more expensive, and thus less often used. Here, aluminium is utilized as a heat sink. There are two kinds of heat sinks: pin-type and straight-type. Heat sinks of the straight kind are used here. The 44°C temperature limit applies to the straight-type heat sink.

Igloo Box:

Polystyrene is the material used to construct the igloo box. Styrene monomer is used to make this synthetic aromatic polymer. Polystyrene comes in two forms: foam and solid. In terms of price and weight, solid polystyrene is the better choice. In many cooling applications, it's utilized as a solid but becomes liquid when heated beyond 100°C.

DC Fan:

Cooler air may be drawn into the case through a fan that also exhausts heated air from inside, or air can be moved over a heat sink to cool a specific component. A fan is often used with active cooling devices. When fans are employed in a peltier module, they are typically paired with a heat sink to provide efficient cooling or heat liberation. Our suggested solution makes use of a brushless dc fan. For just supply, they are the simplest kind of fan, with only two terminals: positive and negative. Peltier would overheat and stop working if not for the fans, which help to keep it cool. For cooling and heating, a dc fan is utilised on both sides of the peltier module.

Transformer:

A step-down transformer is utilized in this instance. A 12V and 40Ah induction transformer is used in this device. In order to save money, the coil is wound using aluminium instead of copper.

Solar Panel:

Solar panel is an electrical device that converts the energy of light directly into the electricity by the photovoltaic effect. The operation of photovoltaic cell requires three attributes. They are;

- The absorption of light, generating electron hole pair.
- Separation of charge carriers of opposite types
- Separate extraction of those carriers to an external circuit.

Assembly of the Hardware Components

Every hardware electrical component that's being utilised is depicted properly connected in the following diagram:. The power source is a 12 Volt 40Ah battery. We're using four Peltier/thermoelectric modules, model no. TEC1-12706, together with a DC fan to keep the heat side of things cool. The temperature in the cabin will be shown on the LCD screen thanks to a thermal sensor called the DS1820. To regulate the temperature, a temperature-controlled relay is utilised.

IV. EXPLANATION OF THE PRESENT SYSTEM

There are two components to the system that has been suggested. They are divided into two categories: main and secondary. The cooling unit is the main component, whereas the heat dissipated is the primary function of the secondary component. The peltier module is a critical component of the system. The module in question is

TEC1-12706. It has a cooling capacity of up to 20°C and is very efficient. The peltier module and dc fan seen above are connected to a heat sink. Their cooling and heating functions are connected via hoses on both sides. This is a DC-only system from top to bottom. This energy is generated by a solar panel. An inverter uses the sun's energy to create a direct current (DC) supply that's then sent to another device. An especially built step-down transformer next receives the inverter's output and converts it to 12V AC. A bridge rectifier is used to convert the AC power back to DC. The peltier module and dc fan now get the anticipated 12 V and 40 A supply. As a result, the peltier module operates according to the peltier effect concept. Peltir module's hot and cold ends are reversed when power is applied to the two terminals. This is accomplished by taking in hot air from one end and releasing it at the other. This is where the cooling happens since it's part of the main circuit. The hot air emitted from the other end may be put to different uses, such as heating water or charging mobile devices, or it can be converted to energy and stored in a battery for later use. Water heating saves money by reducing the need for traditional heaters. The secondary circuit is made up of this. As a result, the whole method is beneficial and may be used everywhere. This is the whole system that has been suggested.

Working Principle:

The system's cooling effect is mostly dependent on the Peltier effect. In the Peltier effect, two electrodes are attached to a sample of semiconductor material and a voltage is applied between them to produce a hot and cold side. The P-N type superconductor's electron-hole is primarily responsible for the heating and cooling effects. As with traditional AC, the electron-hole serves as the system's heat carrier. The Peltier module's cold side is placed within the chamber for cooling, while the hot side is placed outside the chamber for heat removal. The hot side is equipped with a DC fan with fins for easy and fast heat evacuation.

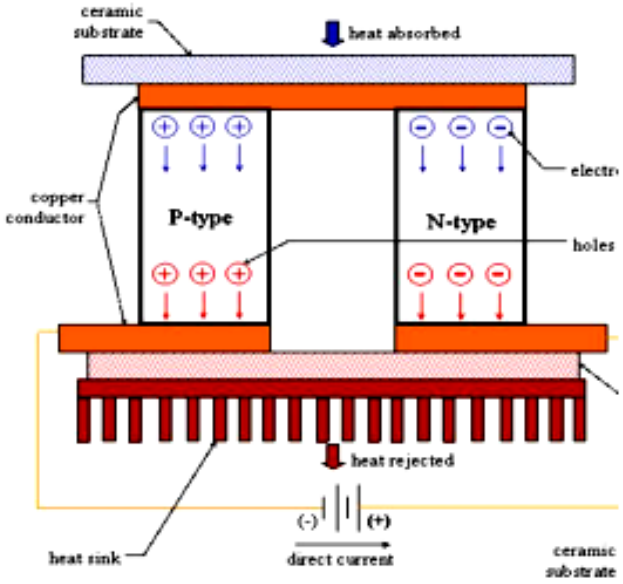

Figure 4: Working of peltier module (adapted from scientific and production firm module - ISO 9001)

V. RESULT AND DISCUSSION

All hardware components must be installed with correct connection in order for the system to be used and to provide the intended result. After turning on the planned system, the following results were obtained:

S NO.	TIME DURATION [IN MIN]	TEMPERATURE
1	0	30^0C
2	21	29^0C
3	31	27^0C
4	39	25^0C
5	45	24^0C
6	54	23^0C
7	62	21^0C
6	TIME INCREASES	STABLE

Advantage of Thermoelectric Module

The advantages of thermoelectric module are as follows:

- Direction of thermoelectric heating pump is¬ reversible by changing the polarity of current, so it can work as cooler and heater too.
- Thermoelectric module does not have moving part to wear and tear; therefore, there is no need of any maintenance.
- It has capacity to work for more than 200,000 hours in steady state.
- It resists shock and vibration.
- It can work in too severe or sensitive environment.
- It does not contain any harmful material like chlorofluorocarbons (CFCs) which can damage environment.
- It does not dependent on gravity. Thus, it can be placed in any direction.
- Temperature can be maintained in fraction of degree, even below ambient temperature using thermoelectric module by controlling the power load provided to the module.
- Temperature can work between 100ºC to - 100ºC of heat sink temperature.
- It can work at extremely low acoustic level by choosing proper heat sink and fan.
- It can be tailored to any size as per the requirement of application.

Disadvantage of Thermoelectric Module

- The main disadvantage of thermoelectric module is lower efficiency when compare to non-thermoelectric modules when working as power generator. It is usually 0.3 or lower.
- Also it has lower co-efficient of production¬ (COP) with range 0f 0.4 to 0.7.

VI. CONCLUSIONS

This environmentally friendly project may be utilized for cooling as well as heating. The suggested concept may be put into action with the help of the right pieces of equipment. Our suggested approach has the potential to provide a respectable level of cooling. Although the prototype works well in confined spaces, a more general-purpose version may be created. There are many benefits to using this system, including its reliance on renewable energy sources, Simpler module, No electricity charges in terms of cost, Cheaper than the traditional method The results indicate that the above-designed system effectively reduces the room's temperature from 310°C to 210°C. By utilizing additional peltier modules, the proposed system can achieve a temperature differential of 100°C. Finally, we'd like to point out that using solar energy, we could have provided conditioned air as well as improved cooling for this system.

REFERENCES

1. Periyasamy R, Hariharan K, Naveen T, Sathish Kumar R, Vaibhav B (2021), Enhancement of Cooling in Solar Air Conditioner using Peltier Module, Annals of R.S.C.B., ISSN:1583-6258, Vol. 25.
2. Rohan Chandra, Rahul, Dr. J.P. Kesari (2020), "Analysis and Design of Thermoelectric Solar Air Conditioning System", International Research Journal of Engineering and Technology (IRJET), Volume 7.
3. Looi, K.K., Baheta, A.T. & Habib, K. (2020), Investigation of photovoltaic thermoelectric air-conditioning system for room application under tropical climate. J Mech Sci Technol 34, 2199–2205. https://doi.org/10.1007/s12206-020-0441-8
4. An, G., Wang, L., Wang, Z. et al. (2019), Study on Working Pairs of Sorption Type Air Conditioner for Electric Vehicles under Different Temperature Zones. J. Therm. Sci. 28, 1004–1014. https://doi.org/10.1007/s11630-019-1132-6
5. Diwania, S., Agrawal, S., Siddiqui, A.S. et al. (2020), Photovoltaic–thermal (PV/T) technology: a comprehensive review on applications and its advancement. Int J Energy Environ Eng 11, 33–54. https://doi.org/10.1007/s40095-019-00327-y
6. Thermodynamic Comparison Of Peltier, Sterling And Vapour Compression Portable Cooler, Applied Energy by Christian.J.L, Jadar R Barbosa in 2011.
7. Mayank Awasthi, K V Mali (2012), ―Design And Development Of Thermoelectric Refrigerator, International Journal of Mechanical Engineering and Robotics, Vol. 1, No. 3, October 2012.
8. M. Eslami, F. Tajeddini and N. Etaati, Thermal analysis and optimization of a system for water harvesting from humid air using thermoelectric coolers, Energy Conversion and Management, 174 (2018) 417–429.
9. M. Chen and G. J. Snyder, Analytical and numerical parameter extraction for compact modeling of thermoelectric coolers, International Journal Heat Mass Transfer, 60 (2013) 689–699.
10. J. Kim, K. Park, D. G. Lee, Y. S. Chang and H. Y. Kim, Optimal cold sink temperature for thermoelectric dehumidifiers, Journal of Mechanical Science and Technology, 32 (2) (2018) 885–895.
11. K. Irshad, K. Habib, F. Basrawi and B. B. Saha, Study of a thermoelectric air duct system assisted by photovoltaic wall for space cooling in tropical climate, Energy, 199 (2017) 504–522.
12. J. Kim et al., Optimal cold sink temperature for thermoelectric dehumidifiers, J. Mech. Science Tech., 32 (2) (2018) 885–895.
13. K. Irshad et al., Study of a thermoelectric air duct system assisted by photovoltaic wall for space cooling in tropical climate, Energy, 119 (2017) 504–522.
14. Z. B. Liu et al., Experimental study and performance analysis of a solar thermoelectric air conditioner with hot water supply, Energy Build., 86 (2015) 619–625.