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Peltier-Based Air Conditioning System

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Abstract: Due to rapid increase of technology the environment gets harmed badly. One of the factors that affect and cause the global warming that is harmful gases like refrigerant and Freon (R22). These gases are used in many places, Air Conditioning System is one of them. Conventional air conditioners release many harmful gases. To overcome this problem "Peltier-Based Air Conditioning System" being introduced. Presented method uses peltier module (Thermoelectric material) which works on Peltier Effect.

Keywords: Thermoelectric; Air Conditioner; Peltier module; Peltier Effect, Economic, Performance.

I. INTRODUCTION

Air conditioning refers to the regulation of air quality for human comfort. While conventional air-cooling methods are effective in providing a comfortable environment, they are not without their faults. These traditional cooling appliances release harmful gases that have been causing damage to the environment over the years, contributing to global warming. However, an emerging alternative for cooling is the utilization of Peltier technology, which makes use of the Peltier effect. Unlike conventional AC systems that use refrigerant gases like Freon and CFCs gases that harm the ozone layer. Peltier air conditioners provide cooling without emitting any type of harmful gases. Additionally, Peltier air conditioners are less expensive compared to conventional ones. The development of a Peltier-operated air conditioner aims to achieve the objectives of cost-effectiveness and eco-friendly cooling. By designing and testing Peltier-operated air conditioners for indoor cooling. This paper is related to provide efficient and environmentally friendly cooling solutions that can replace current conventional air conditioners, which consume a significant amount of electricity and require substantial initial investments.

II. RELATED WORK

W.L Elzanati and S.Y.Yaseen[1] Which compares two air conditioning systems (Solar air conditioning system and DC inverter air conditioning system) in terms of their ability to reduce peak load and cost-effectiveness. The study highlights that the increasing demand for summer air conditioning systems, driven by improved living standards and comfort, has led to increased energy consumption. Additionally, the study suggests that peak loads are often attributed to the use of air conditioning systems in domestic applications. It has been found that the peak load occurs due to domestic applications of air conditioning system.

A.Josh, and A.D.Souza[2] Considered that thermoelectric cooling uses Peltier module that operates on peltier effect. Peltier module, a semiconductor-based material (P-type & N-type) has two sides where heat is absorbed from one side and dissipated on another side. Peltier module consists of several thermocouples sandwiched between two layers of ceramic substrates. The ceramic substrates have high thermal conductivity so that there is minimal conduction resistance across the layer of the substrate but very low electrical conductivity to avoid any leakage current flow through the substrate. When the inside temperature reaches the required condition then thermostat is used to control the inside temperature and power supply to Peltier module will stop.

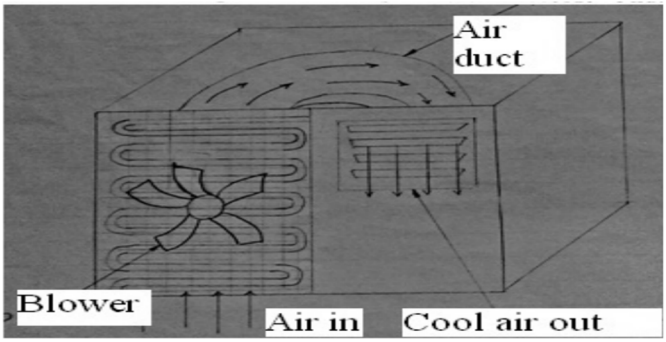

Fig:1 Construction of air conditioner using peltier module showing air cooling circuit.

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N.Zabihi and R.Gouws[3] Verify the power consumption of different topologies of cooling system. To determine the size of photovoltaic panels it's important to know the exact power requirements. Thermoelectric cooling holders are devices that utilize the Peltier effect to create a temperature differential, allowing for the transfer of heat from one side of the device to the other. These holders are commonly used for storing vaccines, as they provide efficient cooling without the need for compressors or refrigerants. To verify power consumption, the cooling holder is connected to a power meter or wattmeter, which measures the electrical power drawn by the device. The power consumption is recorded over a specific time period or under different operating conditions.

Md.Majid[4] Presents the Internet of Things (IoT) and Intelligent Peltier Cold/Hot Air Conditioning system combine modern technology to enhance the functionality and efficiency of air conditioning systems. The Internet of Things refers to the network of interconnected devices, sensors, and systems that can communicate and exchange data with each other through the internet. In the context of air conditioning, IoT allows for remote monitoring, control, and automation of cooling and heating systems. Intelligent Peltier Cold/Hot Air Conditioning systems utilize Peltier devices, which are solid-state heat pumps based on the Peltier effect. Overall, the combination of IoT and Intelligent Peltier Cold/Hot Air Conditioning systems provides enhanced control, energy efficiency, and convenience in managing air conditioning systems, leading to improved comfort, reduced energy consumption, and potentially lower operating costs.

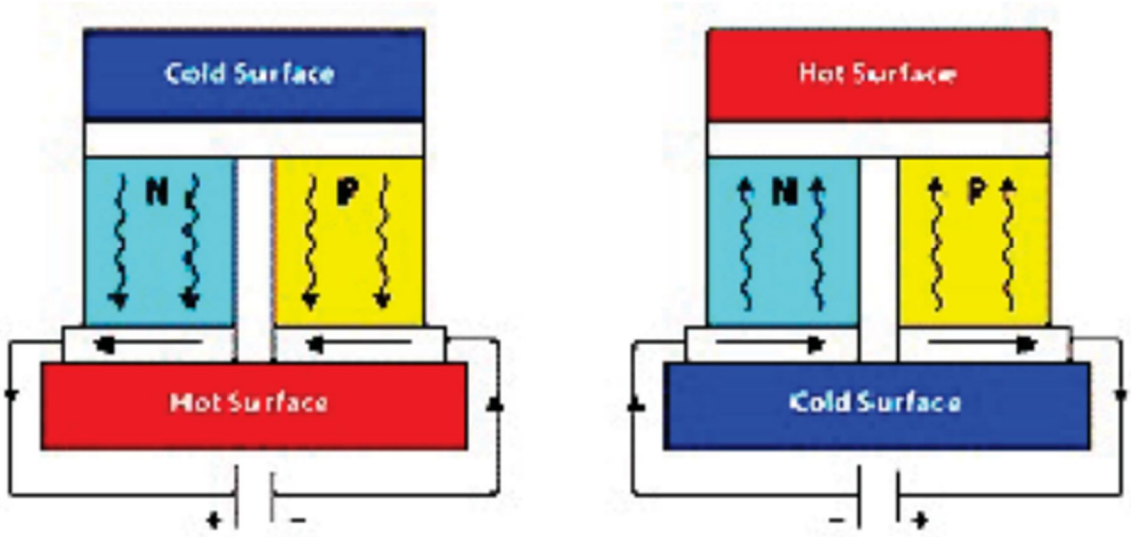

Fig:2 TEC Operation Mode

M.W.Tian[5] Suggested that a cost-effective and performance analysis of thermoelectric cooling systems, specifically focusing on a single TEC-12706 commercial module, can provide valuable insights into its applicability as a building cooling solution. The TEC-12706 module is a commonly used commercial thermoelectric cooling device with specific specifications. It includes heat sink, fans for heat dissipation, and a control system for monitoring and adjusting parameters.

R.Buchalik[6] give the analysis of the Peltier module (thermoelectric material). A thermoelectric air conditioning system utilizes the principle of thermoelectric effect to provide cooling. It operates by harnessing the temperature difference between two dissimilar materials to create an electric current, which in turn generates a cooling effect. In terms of technical analysis, a thermoelectric air conditioning system offers several advantages. First, it has no moving parts, resulting in reduced maintenance and increased system reliability. Additionally, it offers precise temperature control and quick response times, allowing for efficient and convenient cooling. Moreover, thermoelectric systems are compact and lightweight, making them suitable for various applications where space is limited. From an economic standpoint, the initial cost of thermoelectric air conditioning systems tends to be higher than traditional alternatives. The materials used in thermoelectric modules, such as bismuth telluride, are relatively expensive.

H.Moria [7] explained that how the economic factor of peltier air cooler varies under different real working condition. To conduct an exergoeconomic analysis of a Peltier effect air cooler using experimental data, the following steps are typically involved:

1) *Exergy Analysis:* The first step is to perform an exergy analysis to quantify the thermodynamic inefficiencies and losses within the system. This analysis helps identify the major sources of irreversibilities and exergy destruction.

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2) *Exergy Destruction and Costs Allocation:* The exergy destruction within the system is quantified for each component, allowing for the allocation of costs associated with exergy destruction. This step helps identify the components with the highest exergy destruction and potential for improvement.
3) *Cost Accounting:* The costs associated with the system components, such as the Peltier modules, heat sinks, power supply, and other auxiliary equipment, are evaluated. This step involves assessing the capital costs, operating costs, and maintenance costs of each component.
4) *Exergoeconomic Performance Indicators:* Exergoeconomic performance indicators, such as the exergoeconomic factor, exergoeconomic efficiency, and exergy cost rate, are calculated. These indicators provide insights into the cost-effectiveness of the system and help prioritize areas for optimization.
5) *Sensitivity Analysis:* Sensitivity analysis can be performed to evaluate the impact of varying operating conditions, component efficiencies, and cost parameters on the exergoeconomic performance of the Peltier effect air cooler. This analysis helps identify critical parameters that significantly influence the system's economics.

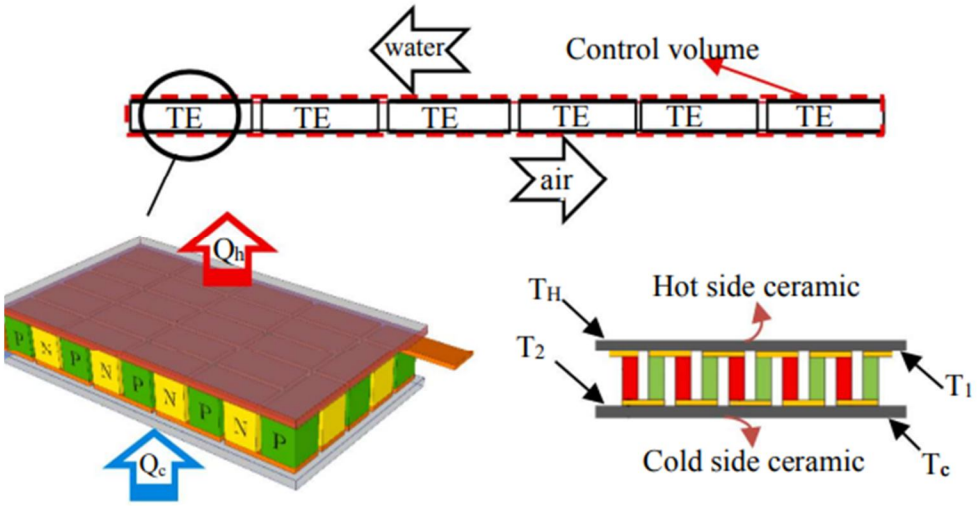

Fig:3 Control volume in the present research

III. RESULT AND DISCUSSION

The goal of this paper [1] is to reduce the peak load via the use of solar energy since the peak load occurs in the hot summer days. Also, it states that saving depends on the number of air conditioners used.

This paper concluded [2] that construction of air conditioner using peltier module is consist of casing (Aluminium) in the shape of rectangular box. For controlling the box temperature thermostat is being used. And when the required temperature is being achieved Peltier modules will be stopped.

Proposed paper[3] is successfully explained these factors likes-Usability, Environment compatibility, Reliability, Testability, Design constructions and simulations, Design constraints, Temperature simulations etc. Also explained that the cost of the power supply increases in power consumption due to the increases in the power rating of the photovoltaic panels and batteries to provide enough power to the TECMs.

This paper [4] provided empirical evidence supporting the advantages of using a Peltier (TEC) module in air conditioners. The findings demonstrate that TEC modules have several strengths, such as being compact in size, operating silently, having minimal vibrations, and being compatible with environmentally friendly energy sources like solar power. This compatibility with clean energy leads to a reduction in energy consumption, making TEC modules eco-friendly by minimizing pollution. However, it is important to note that TEC modules have limitations in terms of their cooling efficiency and capability compared to traditional vapor pressure air conditioning systems.

The experimental analysis[5] revealed promising findings regarding the cost-effectiveness and performance of thermoelectricity as a building cooling system using the TEC-12706 module. The key results are as follows:

1) *Cost-effectiveness:* The TEC-12706 module demonstrated cost-effectiveness as a cooling system for buildings. Its small size and simplicity contribute to lower installation and maintenance costs compared to traditional cooling systems.

2) *Performance:* The performance analysis demonstrated that the TEC-12706 module effectively cools the building. Although it may not match the cooling capability of traditional systems like vapor pressure air conditioning, it still provides satisfactory cooling performance for small to medium-sized spaces. [6] It expressed that thermoelectric air conditioning systems offer unique advantages such as compactness, reliability, and precise temperature control. However, they generally have lower efficiency and higher initial costs compared to conventional cooling systems. Therefore, their suitability depends on the specific application, cooling requirements, and overall economic considerations. Final result of this[7] analysis is that it can provide a comprehensive understanding of the Peltier effect air cooler's performance, efficiency, and cost distribution. It can highlight areas for improvement, guide decision-making for component selection and system optimization, and help determine the overall economic viability of the system.

IV. CONCLUSION

It concluded that for cooling we used refrigerants that produce harmful gases. So, to overcome this we used Peltier Based Air Conditioner. Also, the power consumption of Peltier air conditioner is very less as compare to Conventional air conditioner. It tells about the conceptual design and a unique construction approach for an environmentally friendly and portable Peltier air conditioner, the design and construction method being discussed depart from traditional approaches and offer a distinct solution or innovation in the development of such air conditioner.

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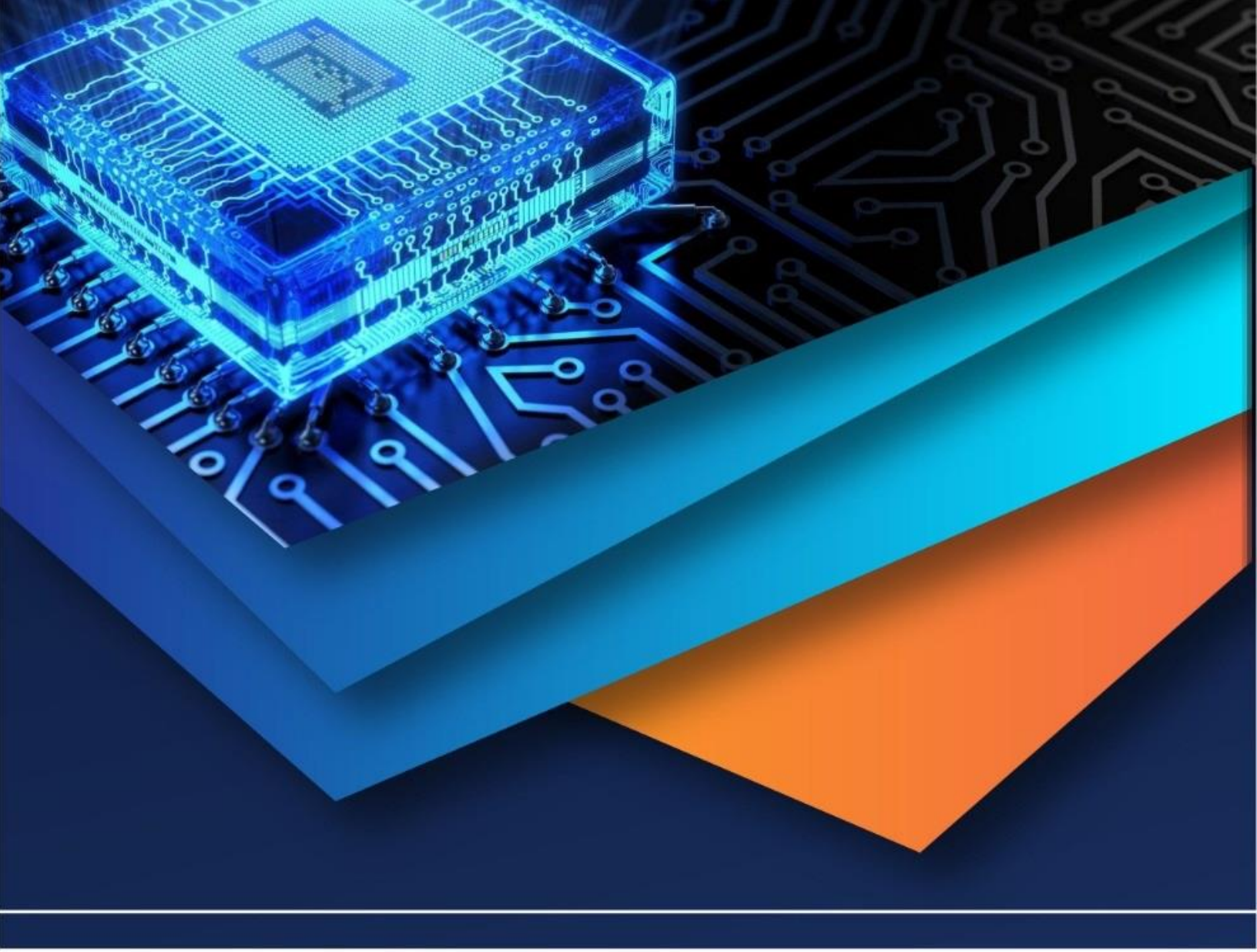

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