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Utilization of Peltier Chipsets in Electric Vehicles to Charge Li-Ion Batteries

Abdalrahman Skheta[1], Onur Akar[2]

[1] Department of Institute of Pure and Applied Sciences, Marmara University, Istanbul, TÜRKIYE
eng.abdulrahman.sk@gmail.com, ORCID: 0000-0003-1600-3495

[2] Department of Electronics and Automation, Marmara University, Istanbul, TÜRKIYE
onur.akar@marmara.edu.tr, ORCID: 0000-0001-9695-886X

***Abstract*— Using the Peltier effect for power generation is a relatively new technology that has been gaining attention in recent years. Using Peltier chips for power generation in EVs is an interesting approach that has the potential to provide a renewable and sustainable source of energy. By using the heat generated by the car's components during operation, the Peltier chips can generate electricity, which can be used to charge the battery. This approach has several benefits, including reducing the reliance on fossil fuels, improving the efficiency of the vehicle, and reducing the carbon footprint of the EV. The Peltier effect is a thermoelectric phenomenon that converts temperature differences into electrical energy to generate enough power to recharge an electric vehicle battery, several Peltier chips can be connected in series, and a converter can be used to convert the generated voltage into a sufficient voltage and can charge the battery. In this paper, an in-depth exploration will be conducted to evaluate the overall effectiveness and efficiency of Pelter chips, with a particular focus on simulating the utilization of these chips through the utilization of Proteus software.**

***Keywords*— Generate electricity, EV, Li-Ion Battery, Peltier, Charge Unit**

I. INTRODUCTION

Securing energy for electric cars poses a significant challenge for manufacturers in the industry. As indicated by a reliable source, the average electric car consumes around 0.20 kWh per kilometer [1]. To enhance vehicle efficiency, manufacturers have two primary options: employing larger capacity batteries or reducing the engine's energy consumption. However, opting for larger batteries results in increased car weight, negatively impacting overall efficiency. On the other hand, reducing engine consumption can compromise vehicle torque, necessitating alternative methods to boost efficiency. According to the same source, electrical transportation in America accounts for approximately 28 percent of the country's total electricity consumption. Table 1 provides insights into the energy distribution among various auxiliary systems. Some electric cars utilize a secondary battery, which is ideal when the vehicle is stationary [2]. Conversely, other vehicles power the subsystems directly from the main battery, leading to energy losses during the conversion process from high battery voltage to low voltage. Introducing the implementation of Peltier technology to charge the secondary battery presents a promising solution to enhance efficiency. By leveraging the thermoelectric properties of Peltier devices, the charging process becomes more efficient, minimizing energy loss and maximizing the overall performance of the secondary battery system [3]. This approach can contribute significantly to the optimization of energy utilization in electric vehicles, addressing the challenges associated with securing energy and improving the overall efficiency of the vehicle.

TABLE I
ENERGY CONSUMPTION OF SOME AUXILIARY SYSTEMS

Auxiliary systems	**Climate control**	**Power steering**	**Braking system**	**Other (lights, media , etc.)**
Part of traction battery energy %	Heating: up to 35%	Up to 5%	Up to 5%	Cooling: up to 30%

According to source [4], one of the major challenges that electric car manufacturers face is ensuring an adequate energy supply for the vehicles. In order to address this issue effectively, employing a method to generate energy proves highly beneficial. Generating a substantial amount of energy would allow for a reduction in battery size, thereby reducing the car's weight and creating more free space within it. Thus, it becomes imperative to explore practical approaches that can minimize the electric car's dependence on external energy sources by utilizing the car's components to generate electricity, covering a portion of the vehicle's power requirements. Several studies have examined the potential of Peltier technology in generating electricity by harnessing heat loss from the engine and exhaust of the vehicle. In their research, [5] [insert study names or authors] delved into the generation of electricity using Peltier modules and explored the use of thermoelectric elements to improve thermal comfort in automobiles. Additionally, studies have focused on the potency of thermoelectric generators for hybrid vehicles, the development [6] of heat extraction systems for automobile applications using Peltier devices, and the utilization of Peltier effects for creating cooling and heating devices for car seats. Furthermore, research has also examined thermoelectric air cooling for cars, optimal design of thermoelectric cooling/heating systems for car seat climate control, and the analysis of cool air ventilated seat covers. In our study, we aim to investigate the possibility and effectiveness of utilizing Peltier technology for electric cars. Transistors within electric cars dissipate a significant amount of energy in the form of heat. Since electric cars incorporate a large number of transistors, we can leverage the temperature rise of these components to generate power. By employing 40 Peltier pieces, we can obtain approximately 60 watts per hour, which corresponds to around 1.8% of the battery capacity of a Nissan Leaf [7].

This research aims to explore the potential of Peltier technology as a viable solution for energy generation in electric cars, tapping into the heat dissipation of transistors to enhance overall energy efficiency.

II. Material And Method

We shall explore the utilization of thermoelectric devices (specifically Peltier devices) for power generation. Thermoelectric devices, being solid-state semiconductor components, have the ability to convert voltage input into a temperature difference. This temperature difference can be harnessed for cooling or heating purposes [8]. Conversely, when a temperature difference is applied to the device, it exhibits the capability to generate direct current (DC) power. Fig. 1 shows the internal structure of the Peltier chip [9].

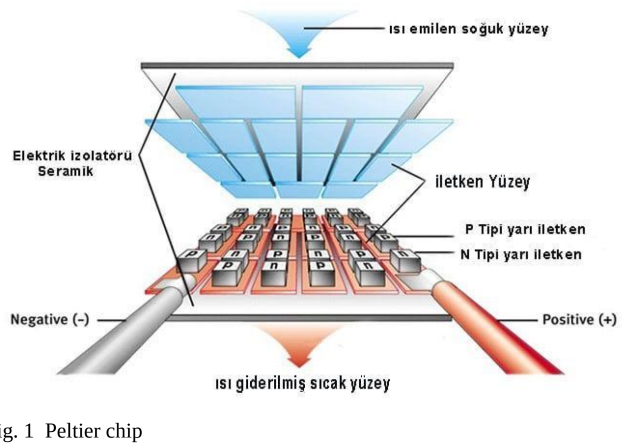

Fig. 1 Peltier chip

A. *The TELBP1-12656-0.45 Peltier chip*

The TELBP1-12656-0.45 Peltier chip stands as an exceptional thermoelectric component. With its advanced design and specifications, this Peltier chip demonstrates remarkable efficiency in converting temperature differentials into electrical power [10]. Its cutting-edge technology and superior materials enable efficient energy generation, making it an ideal choice for various applications that require reliable and sustainable power solutions.

B. *Peltier devices operating mode*

Peltier devices operate in three different modes: cooling mode, heating mode, and power generation mode. Each mode serves a specific purpose and utilizes the unique thermoelectric properties of Peltier devices.

1-Cooling Mode: In cooling mode, a Peltier device functions as a solid-state refrigerator. When a direct current (DC) is passed through the device, it creates a temperature difference across the two junctions of the device. One junction becomes cold while the other junction becomes hot. This temperature differential allows the Peltier device to absorb heat from one side and transfer it to the other side, resulting in cooling at the cold junction. Cooling mode is commonly used in applications such as electronic cooling, thermal management of components, and refrigeration [11].

2-Heating Mode: In heating mode, the polarity of the current passing through the Peltier device is reversed compared to cooling mode. As a result, the temperature difference across the junctions is reversed as well. The side that was previously the cold junction now becomes the hot junction, and vice versa. This mode is used when heat needs to be generated, such as in applications like heating systems, incubators, or maintaining specific temperature conditions.

3-Power Generation Mode: Peltier devices also possess the ability to generate electrical power when subjected to a temperature gradient. This mode is known as power generation mode or the Seebeck effect. When a temperature difference is applied across the junctions of the Peltier device, it induces an electric current. This phenomenon allows the Peltier device to convert waste heat into usable electrical power [12]. Power generation mode has potential applications in energy harvesting, waste heat recovery, and portable power generation.

III. Peltier Applayment in Ev

Within this chapter, our focus will be on delving into the method of utilizing peltries in the context of electric cars and examining its practical application. It is noteworthy that electric vehicles comprise certain components that undergo substantial heating during their operational processes. Specifically, IGBT transistors are known to experience significant heat generation. To counteract this, manufacturers have implemented a radiator system that employs water for cooling purposes, as illustrated [13]. Expanding on the concept further, the integration of peltier devices onto these heat-intensive elements offers a unique opportunity. By capitalizing on the principles of the Seebeck effect, peltier devices can effectively convert thermal energy into electrical energy. This enables the utilization of the otherwise wasted heat to generate electric power through the implementation of peltier chips. The efficacy of employing Peltier Modules in electric cars becomes particularly evident when considering the extensive utilization of IGBT transistors within these vehicles. Whether incorporated in the inverter, converter, or battery management system (BMS), electric cars employ a substantial number of these transistors. Consequently, the integration of Peltier Modules emerges as a remarkably effective means of harnessing the thermal energy produced by these components and converting it into usable electrical power. Thus, through the strategic incorporation of peltier devices onto the heat-emitting elements of electric vehicles, such as IGBT transistors shown in Figure 2, it is possible to optimize the overall energy efficiency of these cars[14]. By effectively converting thermal energy into electrical energy, electric vehicles can not only enhance their performance but also make use of previously wasted energy, thus contributing to a more sustainable and efficient transportation system. Within electric vehicles, a notable abundance of lithium-ion batteries is employed, serving as the fundamental energy storage solution.

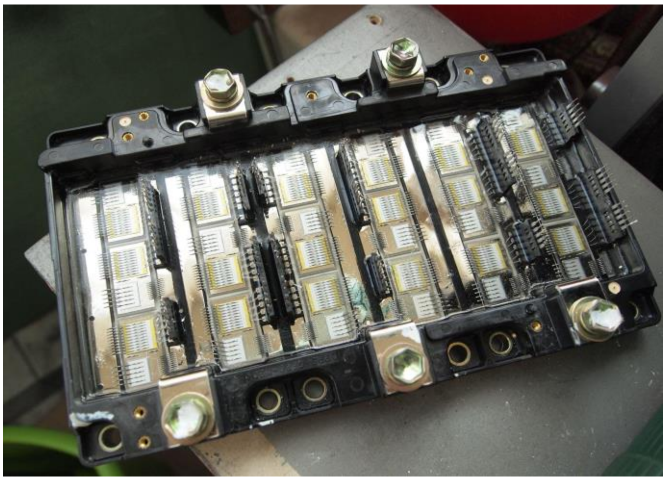

Fig. 2 The power boards in the EV inverter

A. *Charging Circuit*

To ensure efficient charging of the battery, it is essential that the voltage generated by the peltiers is not only sufficient but also compatible with the battery's specific charging requirements. Consequently, the utilization of a DC-DC Converter becomes imperative in order to convert the voltage produced by the peltiers into a suitable charging voltage that can effectively replenish the battery's energy reserves. Given that the primary source of energy generation in this context is the peltier device, it is crucial to employ a converter equipped with a feedback mechanism. This feedback feature is vital because the input voltage, which is the power generated by the peltiers, exhibits variability depending on the prevailing temperature conditions. By incorporating a feedback loop, the converter can dynamically adjust and regulate the output voltage to accommodate these fluctuations, thereby ensuring a stable and reliable charging process for the battery. Visualizing the overall system, presents a comprehensive diagram that illustrates the interconnections and components involved in the process of charging the battery using peltiers. This visual representation provides a clear understanding of how the various elements integrate harmoniously to facilitate the efficient transfer and conversion of energy, ultimately leading to the successful charging of the battery. Figure 3.

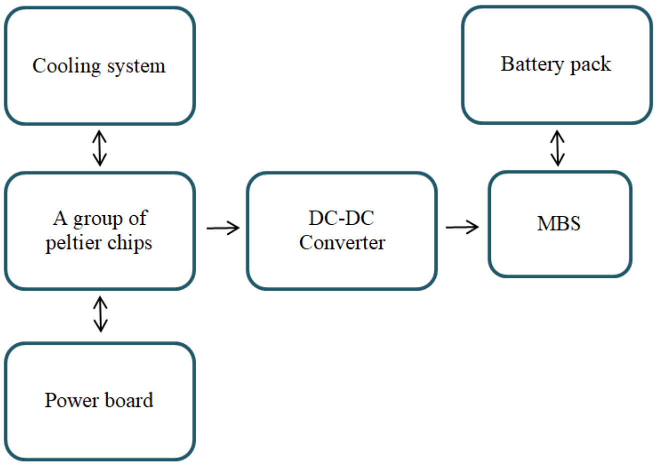

Fig. 3 Diagram of Battery charging by peltiers

IV. Results

The quantity of energy generated relies on the presence of elements prone to overheating during operation. As the number of these elements increases, the opportunity to utilize more Peltier modules arises. Additionally, the magnitude of heat emitted by these elements plays a crucial role, especially considering that batteries in electric vehicles tend to experience elevated temperatures, presenting an avenue for electric energy generation [15]. For instance, the average temperature of an IGBT, ranging from 40 to 160A, reaches approximately 160°C [16]. At this temperature, a Peltier device can effectively generate electrical energy, leveraging a heat difference of around 125°C between its two sides [17]. When an aluminum heatsink is employed, the Peltier module's output power is estimated to be around 3.5 watts. However, maintaining a significant temperature difference between the two faces of the Peltier module remains challenging due to its thin thickness [18]. To address this challenge, an aluminum heatsink can be utilized, and the airflow generated during driving can be harnessed to cool the heat exchanger. While fans can be employed for cooling, it is important to consider their electrical energy consumption, necessitating a pilot study to assess their efficiency. Figure 6 showcases the relationship between the increased power generated by the Peltier module and the rising temperature [19]. For instance, at a temperature of 50°C, the Peltier module generates approximately 3.5 watts (according to the data sheet of TELBP1-12656-0.45). By employing a substantial number of Peltier modules, a relatively effective amount of energy can be obtained. For instance, when 120 Peltier modules are connected in series, the total energy generated would be 420 watts (3.5 × 120). Alternatively, if radiator water is utilized to cool the transistors, reducing the temperature to around 30°C, each Peltier module would generate approximately 4.5 watts. Consequently, the total energy generated by 120 Peltier modules would be 540 watts (4.5 × 120).

Figure 4and Figure5 show the amount of energy produced from Peltier chipsets per day and year. The Power Supply Based on Peltier showcased in proves to be a cost-effective solution, resulting in significant savings.

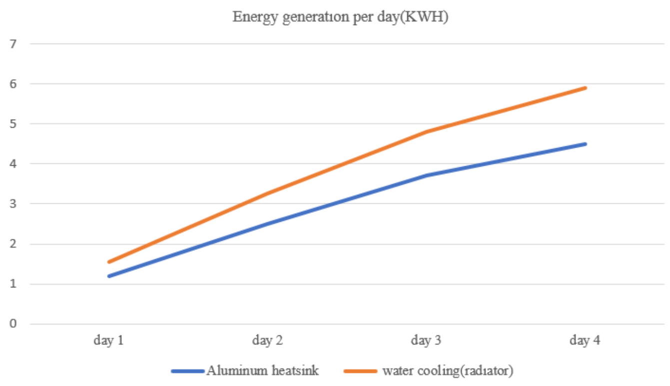

Fig. 4 The amount of energy produced per day

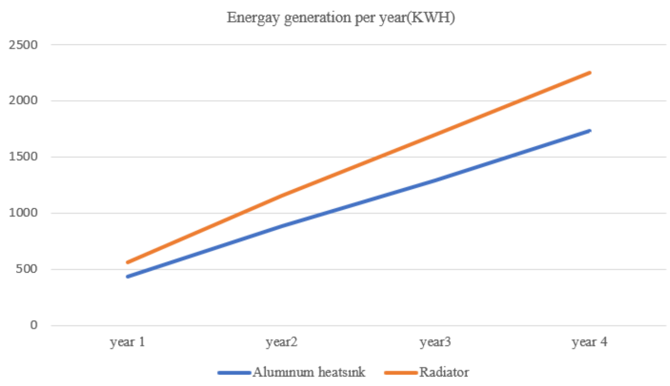

Fig. 5 The amount of energy produced per year

As stated in Table 2, considering that a single Peltier module is priced at $4, the expenditure for 120 modules sums up to $480. Additionally, incorporating a 200 W DC-DC converter with feedback adds an approximate cost of $50 to the project. Thus, the total outlay for the entire endeavor is estimated to be around $530. Serves as a comprehensive reference, illustrating the substantial monetary benefits that can be attained through the utilization of Peltier chips for power production. A careful analysis of the Table 2 data reveals that the investment made in the Peltier chip system can be recovered within a remarkably short span of three and a half years.

TABLE II
THE AMOUNT OF MONEY SAVED WHEN USE POWER SUPPLY BASED ON PELTIER

Year	1	2	3	4	5
The amount of money saved when using an aluminum cooler($)	150	300	450	600	750
The amount of money saved when using the radiator($)	195	390	585	780	975

By opting for the Power Supply Based on Peltier and capitalizing on the cost-efficient properties of the technology, users can not only enjoy the advantages of energy generation but also witness their initial financial outlay gradually compensated over time. Such findings further highlight the viability and potential long-term benefits associated with incorporating Peltier chips into power supply systems.

V. CONCLUSION

We can deduce that incorporating peltier chips into electric cars results in favorable efficiency. By utilizing approximately 120 units of peltier chips, we can achieve an output of around 400 watts. This energy output proves to be effective and holds the potential to positively impact the advancement of electric car manufacturing. Consequently, implementing peltier chips can lead to increased driving range for vehicles or provide additional free space by reducing the size and weight of the battery. However, this concept is still in its nascent stage and requires further investigation to determine the extent of its effectiveness in electric cars and the amount of energy each vehicle can generate based on its specific model. It is thought that this study will make a great contribution to future studies.

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