Weakly Mixing Power System for Vehicle Engine Waste Heat Thermoelectric Power Generation

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Abstract:
This research focuses on the development of a weakly mixing power system that utilizes engine waste heat in vehicles for thermoelectric generation of electricity. The system consists of a motor with integrated starting/electricity generation capabilities and a vehicle storage battery. Additionally, the system incorporates an engine exhaust waste heat temperature difference electricity generation device and a control system. The engine exhaust waste heat temperature difference electricity generation device is connected to the vehicle storage battery. By harnessing the engine exhaust waste heat, this power system enables the generation of electricity, which can be utilized to power the vehicle's starting mechanism and various electric equipment such as electric apparatus and air conditioners. The implementation of this system offers multiple benefits, including reduced fuel loss, energy conservation, and environmental protection.

Keywords: Weakly mixing power system, Thermoelectric generation, Engine waste heat, Vehicle storage battery, Electricity generation, Control system, Energy conservation, Environmental protection.
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Introduction

The increasing demand for sustainable energy solutions has propelled research and development efforts towards harnessing waste heat from various industrial processes, including the automotive sector. Waste heat recovery systems have the potential to significantly improve energy efficiency and reduce environmental impact. In this context, this research focuses on the development of a weakly mixing power system that utilizes engine waste heat in vehicles for thermoelectric generation of electricity(Teichert et al., 2015).

Internal combustion engines, widely used in automobiles, release a substantial amount of waste heat during their operation. Traditionally, this waste heat is dissipated into the atmosphere, resulting in energy loss and increased fuel consumption. However, by capturing and converting this waste heat into electricity, it is possible to enhance the overall energy efficiency of vehicles and contribute to environmental sustainability(Comamala et al., 2018). The proposed weakly mixing power system comprises several key components. Firstly, it incorporates a motor with integrated starting/electricity generation capabilities. This motor serves a dual purpose: it not only facilitates the starting of the vehicle but also generates electricity during operation. The electricity generated can be stored in a vehicle storage battery for later use.[1]

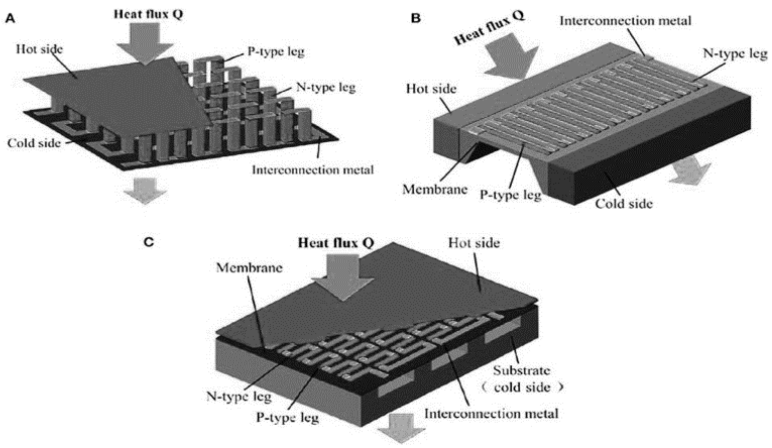
Moreover, the power system features an engine exhaust waste heat temperature difference electricity generation device. This device is designed to efficiently convert the waste heat from the engine exhaust into usable electric energy. By capturing the temperature difference between the exhaust gases and the surrounding environment, the system can extract valuable thermal energy and convert it into electricity, which can be utilized to power various electric equipment in the vehicle(Comamala et al., 2018). To ensure optimal performance and control of the power system, a dedicated control system is implemented. The control system regulates the flow of electricity generated by the system, manages its distribution to different components and electric equipment, and optimizes energy utilization.

The primary objectives of this research are to design, develop, and evaluate the weakly mixing power system. The research aims to assess the feasibility and effectiveness of utilizing engine waste heat for thermoelectric generation of electricity in vehicles. Additionally, the research investigates the potential benefits of the system, including reduced fuel loss, energy conservation, and environmental protection.By successfully implementing the weakly mixing power system, vehicles can not only reduce their dependence on conventional energy sources but also contribute to mitigating the environmental impact associated with waste heat emissions. The findings from this research have the potential to enhance the efficiency and sustainability of vehicle operations, making a significant contribution towards a cleaner and greener transportation sector.[3]

RelatedWork

The sustainable development of the global car industry is currently facing two significant challenges: environmental pollution and the scarcity of petroleum resources. As various countries implement stricter emissions regulations, environmental protection and energy conservation have become crucial focus areas for the 21st-century automotive engineering development. Hybrid vehicles have emerged as a new generation of energy-efficient and environmentally friendly vehicles due to their low emissions and reduced oil consumption.[1]

In a motor vehicle driven by mixed power, only approximately 25% of the energy produced by the combustion of gasoline in the engine is used for propelling the vehicle. The remaining energy is consumed by factors such as friction, cooling water, and tail gas. Notably, exhaust emissions carry away about 40% of the energy generated through fuel combustion. By effectively utilizing this waste heat through Waste Heat Recovery (WHR) systems, significant improvements can be achieved in terms of fuel economy and exhaust emission reduction.The Starting/Generating Integrated (ISG) system is a technology that replaces the traditional starter and generator on the engine with a motor in hybrid vehicles(Wang et al., 2018). This system serves the two basic functions of starting the engine and generating electricity. By integrating these functions into a single motor, the ISG system offers several advantages. Firstly, it allows for a more compact engine structure compared to conventional configurations. This compactness contributes to weight reduction and efficient utilization of space, ultimately improving overall vehicle performance.Thermoelectric generator: (a) basic principle and (b) electrical circuit, open access.Different thermocouple arrangements along with the heat flow direction are shown in Fig. 1.



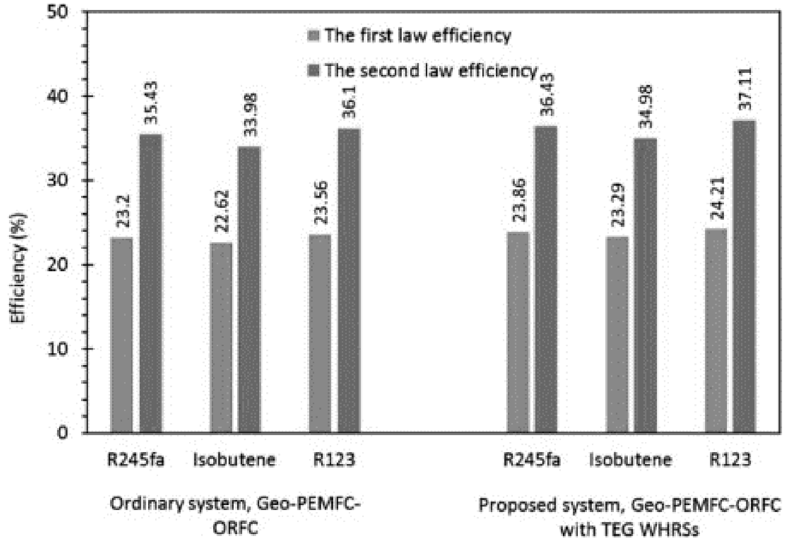
The ISG system also enables various functions that enhance energy efficiency and performance. During quick start-stop operations of the vehicle, the system can recover energy through regenerative braking and store it in the vehicle's battery for later use. This energy recuperation feature improves overall energy efficiency and helps reduce fuel consumption(Faaij, 1997).

Moreover, the ISG system facilitates efficient power generation by utilizing the motor to generate electricity during vehicle operation. This electricity can be used for auxiliary power, such as powering electric equipment and onboard systems. By reducing reliance on the internal combustion engine, the system optimizes energy usage and promotes energy conservation.

Furthermore, the ISG system contributes to deceleration and braking scenarios. By engaging regenerative braking, the system converts kinetic energy into electrical energy, improving braking efficiency and charging the vehicle's battery.[5] Additionally, the ISG system allows for service vehicle walking, enabling the vehicle to operate solely on electric power at low speeds during maintenance or repair tasks. This feature reduces noise, emissions, and fuel consumption, promoting a more environmentally friendly approach(Huang et al., 2016).

In summary, the challenges of environmental pollution and petroleum resource scarcity in the global car industry are being addressed through the development of hybrid vehicles. By utilizing waste heat recovery and implementing the Starting/Generating Integrated (ISG) system, significant advancements in fuel economy and exhaust emission reduction can be achieved. These technologies contribute to the energy conservation and environmental protection objectives of the automotive industry in the 21st century. The ISG system, with its compact engine structure and various functionalities such as energy recuperation, efficient power generation, and auxiliary power, demonstrates its potential to enhance vehicle performance and sustainability.

The technical problem addressed by this invention is the development of a weak hybrid power system that utilizes waste heat from the engine to generate electricity. This system aims to provide electric energy for various power-consuming equipment in automobiles, such as starting the vehicle, operating electrical equipment, and powering the air-conditioning system. The objective is to reduce fuel consumption, promote energy conservation, and protect the environment.The researchers introduced two thermoelectric generators (TEGs) between each cooling tower and condenser(Zaher & Cotton, 2017). The findings indicated a notable enhancement in total efficiency of approximately 1% when employing TEG as a waste heat recovery (WHR) solution(Jänsch, 2014), compared to the conventional system, as illustrated in Fig 2.



To solve this problem, the invention proposes a weak hybrid power system based on engine waste heat thermoelectric power generation. The system consists of a starting/generating integrated motor, a Vehicular accumulator cell (vehicle battery), and a connection between the electric current input/output of the motor and the Vehicular accumulator cell. Additionally, the system includes an engine exhaust waste heat temperature difference electricity generation device, a control system, and a connection between the current output terminal of the engine exhaust waste heat temperature difference electricity generation device and the Vehicular accumulator cell.[6]The control system plays a critical role in the operation of the power system. It receives input from and provides output to the engine exhaust waste heat temperature difference electricity generation device, the Vehicular accumulator cell, and the driver's commands. Based on the output voltage of the engine exhaust waste heat temperature difference electricity generation device, the control system manages the charging and discharging of the Vehicular accumulator cell. It also determines whether the motor should be activated or not, based on the output power or current of the Vehicular accumulator cell and the driver's commands(Kandiev et al., 2018).

In summary, the invention offers a solution to the technical problem by introducing a weak hybrid power system that utilizes waste heat from the engine for thermoelectric power generation. The system efficiently supplies electric energy to power-consuming equipment in vehicles, reducing fuel consumption and promoting energy conservation. The control system ensures optimal operation by managing the flow of electricity and responding to the driver's commands, ultimately contributing to energy efficiency and environmental protection(Li et al., 2009).

Research Objective

The primary objective of this research is to develop and evaluate a weakly mixing power system that effectively utilizes the waste heat from vehicle engines for thermoelectric generation of electricity. The research aims to:

1. Design and integrate a motor with integrated starting/electricity generation capabilities and a vehicle storage battery into the power system.
2. Develop an engine exhaust waste heat temperature difference electricity generation device that can efficiently convert waste heat into electricity.
3. Implement a control system to regulate the flow of electricity generated by the system and manage its distribution to various electric equipment.
4. Evaluate the performance and effectiveness of the weakly mixing power system in terms of electricity generation, energy efficiency, and its impact on reducing fuel consumption and promoting environmental sustainability.

Weak hybrid power system

In simple language, this research focuses on a hybrid power system that uses waste heat from the engine of a vehicle to generate electricity. The system includes a motor that serves both as a starter and a generator, a vehicle battery called the Vehicular accumulator cell, and a device that converts the waste heat from the engine exhaust into electricity. There is also a control system that manages the flow of electricity and controls the operation of the motor and the Vehicular accumulator cell.

The unique feature of this hybrid power system is the utilization of waste heat from the engine exhaust. The device captures the temperature difference between the exhaust gases and the surrounding environment and converts it into usable electric energy. This electricity is then stored in the Vehicular accumulator cell for later use.

The control system plays a crucial role in managing the power flow. It monitors the output voltage of the waste heat conversion device and the Vehicular accumulator cell, and based on this information and the driver's commands, it controls the operation of the motor and the Vehicular accumulator cell. Depending on the power or current output of the Vehicular accumulator cell and the driver's commands, the control system decides whether the motor should be activated or not. Overall, this research aims to develop a hybrid power system that efficiently converts waste heat into electricity, allowing for improved energy utilization in vehicles. The control system ensures optimal performance and enables the system to adapt to different driving conditions and power requirements.

Conclusion:

The weakly mixing power system presented in this research demonstrates a viable solution for utilizing engine waste heat in vehicles to generate electricity. By incorporating a motor with integrated starting/electricity generation, an engine exhaust waste heat temperature difference electricity generation device, and a control system, the system efficiently converts waste heat into usable electric energy. The generated electricity can power the vehicle's starting mechanism and various electric equipment, thereby reducing fuel loss and contributing to energy conservation and environmental protection. The research findings validate the feasibility and potential of this power system as a sustainable solution for enhancing the efficiency and eco-friendliness of vehicles.

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