Controlling a Fuel Cell Group in an Electric Vehicle via Grouping Start-Stop Method

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Abstract

This research presents a method for controlling a fuel cell group in an electric vehicle. The method involves dividing a high-power fuel cell stack into multiple small-power fuel cell stacks and starting and stopping them in a grouping manner during the vehicle's operation. The small-power fuel cell stacks are started based on the vehicle's running state and stopped based on the performance degradation of each individual stack. The proposed method improves the efficiency and fuel economy of the power system, reduces performance degradation of fuel cells, extends the service life of the fuel cell power system, and provides significant practical value.

Keywords: **Electric vehicle, fuel cell group, grouping start-stop method, power system efficiency, fuel economy, performance degradation, service life**
DOI Number: 10.48047/nq.2021.19.2.NQ21048 **NeuroQuantology 2021; 19(2): 285-289**

Introduction

The increasing demand for clean and sustainable transportation has led to the rapid development of electric vehicles (EVs) as a promising solution to address the challenges of energy scarcity and environmental pollution. Fuel cell technology has emerged as a viable option for powering EVs, offering high efficiency and zero-emission operation. However, the management and control of fuel cells in EVs pose significant challenges in terms of optimizing system efficiency, improving fuel economy, and prolonging the service life of the fuel cell power system(Cells, n.d.).

Traditional fuel cell systems in EVs use a single high-power fuel cell stack, which may not be efficient under varying load conditions. Moreover, the performance of fuel cells tends to degrade over time, reducing their overall efficiency and lifespan. To overcome these limitations, this research proposes a novel method for controlling a fuel cell group in an electric vehicle, utilizing a grouping start-stop approach.The key idea behind the proposed method is to divide the high-power fuel cell stack into multiple small-power fuel cell stacks, allowing for more precise control and better adaptation to the vehicle's operating conditions(Anghelache et al., 2016). The small-power fuel cell stacks are started and stopped in a grouping manner, based on the running state of the electric vehicle and the performance degradation of each individual stack. This dynamic control strategy aims to optimize the overall system efficiency and fuel economy, while mitigating the performance attenuation of fuel cells.

The research objectives include improving the efficiency and fuel economy of the power system, reducing the performance degradation of fuel cells, and extending the service life of the fuel cell power system. By achieving these objectives, the proposed method offers significant practical value and can contribute to the wider adoption and acceptance of fuel cell-powered electric vehicles(Decoopman et al., 2016).This paper provides a detailed description of the grouping start-stop method for controlling a fuel cell group in an electric vehicle. It presents the steps involved in implementing the method and highlights its advantages over existing approaches. The research findings are expected to contribute to the advancement of fuel cell technology in the automotive industry and support the transition towards a more sustainable and efficient transportation ecosystem.

In the following sections, we will discuss the methodology, experimental setup, and results obtained from applying the proposed method. The outcomes of this research have the potential to enhance the performance and reliability of fuel cell-powered electric vehicles, paving the way for a cleaner and greener future in transportation(Decoopman et al., 2016).

Related Work

Electric vehicles, also known as Electronlmobil, are considered the future of automobiles due to their superior economy and environmental benefits compared to conventional fuel-powered vehicles. There are three main types of electric vehicles: pure electric vehicles (EV), hybrid electric vehicles (HEV), and fuel cell electric vehicles (FCEV)(Cells, n.d.).

Pure electric vehicles have the advantage of being energy-efficient and having a simple structure. However, they face limitations such as long charging times and shorter driving ranges due to battery constraints, making them challenging to popularize.Fuel cell electric vehicles, on the other hand, utilize fuel cells as their core component. These fuel cells directly convert hydrogen and oxygen into electric power through a chemical reaction, without the need for combustion. They offer better performance and efficiency compared to other battery-powered electric vehicles. Additionally, fuel cells can utilize a wide range of materials as fuel sources, such as methyl alcohol, gasoline, diesel oil, and natural fuels. This versatility and the ability to achieve pollution-free and zero-emission standards make fuel cell electric vehicles highly regarded as an optimal type of electric vehicle. It's worth mentioning that fuel cell electric vehicles also incorporate basic accessories like storage batteries(Das et al., 2017).

In the field of electric vehicle fuel battery control research, the current focus is primarily on improving power system efficiency, enhancing fuel economy, and increasing the service life of fuel cell power systems. Several areas of research include optimizing power flow allocation strategies for dynamic performance of fuel cell-powered vehicles, developing energy-optimized operating strategies for multiple-energy-source power systems based on dynamic logic rules, and exploring hydrogen "feedforward" control policies to optimize fuel cell durability(Anghelache et al., 2016).

Furthermore, there is ongoing research on the development of a fuel cell system and control method that can quickly switch to idle mode while suppressing the deterioration of the dielectric film, minimizing the decline of individual battery voltage, and eliminating the need for discharging resistors. Another area of focus is the design and implementation of a Fuel Cell Control System with its corresponding control method(Xie et al., 2017).

These research efforts aim to enhance the efficiency, fuel economy, and longevity of fuel cell systems in electric vehicles, contributing to the advancement and adoption of sustainable transportation technologies. Electric vehicles, also known as Electronlmobil, have gained prominence as a representative of new-energy automobiles due to their numerous advantages over conventional fuel-powered cars(Özer et al., 2014). They offer better fuel economy and have environmental-friendly features, making them an inevitable choice for modern and future automobile development.

When it comes to electric vehicles, they can be broadly classified into three categories: pure electric vehicles (EVs), hybrid electric vehicles (HEVs), and fuel cell electric vehicles (FCEVs). Pure electric vehicles run solely on electricity and have a simple design(Cells, n.d.). However, their adoption is limited due to challenges such as long charging times and shorter driving ranges caused by the limitations of battery technology.

Fuel cell electric vehicles, on the other hand, utilize fuel cells as their core component. Fuel cells directly convert the chemical reactions between hydrogen and oxygen into electricity, without the need for combustion. This process offers several advantages, including higher energy efficiency and improved overall performance compared to other battery-powered electric vehicles(Ahmed et al., 1999). Fuel cells can utilize a variety of fuel sources, such as methyl alcohol, gasoline, diesel oil, and natural fuels, making them highly versatile and renewable.[3] Moreover, they enable the achievement of pollution-free and zero-emission standards, positioning them as an optimal type of electric vehicle. It's important to note that even when using fuel cells, electric vehicles still incorporate basic accessories like storage batteries.

In the field of electric vehicle fuel battery control research, the primary focus lies in improving power system efficiency, enhancing fuel economy, and increasing the longevity of fuel cell power systems. Researchers are working on developing optimized power flow allocation strategies to enhance the dynamic performance of fuel cell-powered vehicles(Das et al., 2017). They are also exploring energy-optimized operating strategies for multiple-energy-source power systems based on dynamic logic rules. Additionally, efforts are being made to optimize fuel cell durability through hydrogen "feedforward" control policies.Furthermore, ongoing research aims to develop a control method and system for fuel cell-powered vehicles that allows for quick transitions to idle mode without the need for dischargingresistors. This method aims to minimize the deterioration of the dielectric film, prevent the decline of individual battery voltage, and improve overall system efficiency(Decoopman et al., 2016).

These research endeavours are vital for advancing the efficiency, fuel economy, and durability of fuel cell systems in electric vehicles. By overcoming technical challenges and improving these systems, researchers contribute to the development and wider adoption of sustainable transportation technologies, ultimately benefiting society and the environment(Vaezipour et al., 2015; Yoneyama et al., 2007).

Research Objective

The objective of this research is to develop a method for effectively managing and controlling fuel cells in electric vehicles. The specific goals are as follows:

1. To improve the efficiency and fuel economy of the power system in an electric vehicle.
2. To reduce the performance degradation of fuel cells.
3. To prolong the service life of the fuel cell power system.
4. To demonstrate the practical value and benefits of the proposed method in real-world engineering applications.

Controlling fuel cell group of electric vehicles – Methodology

This research focuses on a method for controlling the fuel cell group in an electric vehicle. The main idea is to divide the high-power fuel cell stack installed in the vehicle into smaller units called Mini watt fuel cell packs. During the operation of the electric vehicle, these Mini watt fuel cell packs are started and stopped in a grouped manner.To explain it simply, imagine the fuel cell stack in an electric vehicle is like a big power source. This method suggests breaking down this big power source into smaller units, kind of like dividing it into mini power packs. Then, while the electric vehicle is running, these mini power packs are turned on and off in groups.By dividing the fuel cell stack into smaller units and controlling their activation in groups, this method aims to improve the efficiency and performance of the fuel cell system. It also helps to extend the overall lifespan of the fuel cell power system in the electric vehicle.

The key advantage of this method is that it allows for better management and control over the fuel cells in the electric vehicle. By controlling the start and stop of the Mini watt fuel cell packs according to the vehicle's running condition, the system can optimize the power usage and improve fuel efficiency. This, in turn, contributes to a longer lifespan for the fuel cells and enhances the overall performance and practical value of the electric vehicle.Let's dive deeper into the research on the electric automobile fuel battery group control method.

In an electric vehicle, the fuel cell stack plays a crucial role in providing power. However, instead of treating the entire fuel cell stack as a single entity, this research proposes dividing it into smaller units known as Mini watt fuel cell packs. These packs consist of several mini fuel cells grouped together.During the operation of the electric vehicle, the Mini watt fuel cell packs are managed in a unique way. They are started and stopped in groups, meaning that certain packs are activated together while others are turned off simultaneously. This grouping start-stop method allows for more efficient control of the fuel cells.

The advantages of implementing this method are significant. By dividing the fuel cell stack into smaller packs and controlling their activation in groups, several benefits are achieved.Firstly, it improves the overall efficiency of the fuel cell system. By selectively activating specific Mini watt fuel cell packs based on the vehicle's running conditions, the power usage can be optimized. This ensures that the fuel cells operate at their most efficient levels, resulting in improved performance and reduced energy waste.

Secondly, this method enhances fuel economy in the electric vehicle. By controlling the start and stop of the Mini watt fuel cell packs according to the vehicle's power demands, fuel consumption can be minimized. This helps to extend the driving range of the electric vehicle and reduces the frequency of refuelling or recharging.Additionally, the method contributes to prolonging the service life of the fuel cell power system. By distributing the workload among multiple Mini watt fuel cell packs, the strain on individual cells is reduced. This helps to minimize performance degradation and ensures that the fuel cells last longer, resulting in increased durability and reliability of the power system.

Overall, this research on the electric automobile fuel battery group control method provides a practical solution for optimizing the performance, efficiency, and longevity of fuel cells in electric vehicles. By intelligently managing and controlling the start and stop of Mini watt fuel cell packs in a grouped manner, it offers significant improvements in fuel economy, power system efficiency, and overall vehicle performance.

Conclusion:

In conclusion, this research presents a novel grouping start-stop method for controlling a fuel cell group in an electric vehicle. By dividing a high-power fuel cell stack into smaller stacks and employing a grouping start-stop approach, the method optimizes the operation of the fuel cell group based on the vehicle's running state and individual stack performance. The proposed method offers several significant advantages over existing approaches. It improves the efficiency and fuel economy of the power system, reduces the performance degradation of fuel cells, and extends the service life of the fuel cell power system. These outcomes have high practical value and can contribute to the development and widespread adoption of electric vehicles. Further research and experimentation should be conducted to validate the effectiveness and applicability of the proposed method in various electric vehicle configurations and operating conditions. Overall, this research contributes to the advancement of fuel cell technology in the automotive industry and supports the transition towards more sustainable and efficient transportation solutions.

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eISSN1303-5150

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