

## Current Status and Prospects of Internal State Management in Vehicular Fuel Cell Systems

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**Abstract:** The proton exchange membrane (PEM) fuel cell system is emerging as a promising contender for future electric vehicle power sources. However, its broad-scale deployment is hampered by its limited lifespan. Under the vehicular dynamic conditions, the degradation of PEM fuel cells is predominantly attributed to improper management of internal state levels, such as insufficient reactant concentration, lower membrane water content, and excessive liquid water within porous media. To facilitate subsystem management for extracting full power and prolonging the lifespan of the PEM fuel cell system, it is critical to implement real-time monitoring of internal states. This allows for responsive feedback control, ensuring the maintenance of internal states at their optimal levels. Nevertheless, direct measurement of internal states within the vehicular environment proves challenging due to the enclosed construction of the PEM fuel cells. Therefore, the urgent challenge to address is how to identify internal states of the PEM fuel cell online using existing measurement methods and implement precise control accordingly. This report presents the cutting-edge technologies for the internal state identification, discussed the status quo of control strategies for hydrogen, air, and thermal subsystems, and ultimately provide an outlook on the evolution of digital and intelligent technologies in the fuel cell system management.

**Keywords:** PEM fuel cell; internal state



Haifeng Dai, a professor and doctoral supervisor at Tongji University and a distinguished "Eastern Scholar" professor in Shanghai, has dedicated career to the research of power sources for new energy vehicles. He has directed over 40 scientific projects, including key initiatives funded by NSFC. As the first or corresponding author, he has published more than 90 SCI-indexed papers in journals like Nature Communications, accumulating over 8,000 citations with an H-index of 48. From 2019 to 2023, he was consistently named an Elsevier Highly Cited Chinese Researcher and ranked among the top 2% of global scientists for lifetime scientific impact. He holds 49 patents, with 6 transferred, has contributed to 8 standards, authored 5 Chinese monographs and 1 symposium as the first author, and co-authored 6 monographs in both Chinese and English. As a senior IEEE member and senior member of the SAE China, he serves as associate editor or editorial board member for 7 academic journals, including JES and RSER. He has been awarded one Shanghai Science and Technology Progress Award, four provincial and ministerial-level first-class science and technology awards, and one gold medal at the GIEI as the principal contributor.