Design and Optimization of Air Supply System Control Strategy of Full-Power Fuel Cell Vehicle Integrated with Short-Term Power Prediction

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Abstract:

Proton exchange membrane fuel cells (PEMFC) have attracted extensive attention in vehicle applications due to their advantages of zero-emission, high efficiency, and fast filling speed [1]. However, due to load cycling, the performance, lifespan, and durability of full-power fuel cell vehicles (FPFCV) still need to be further improved [2]. Load cycling is more likely to cause degradation of fuel cell materials [3]. Carbon catalyst supports can lead to the loss and degradation of platinum owing to fuel starvation and corrosion at the hydrogen-air interface [4]. The dynamics of the fuel cell system (FCS) are very important due to the hysteresis of the gas supply. Poor dynamic response is more likely to lead to gas insufficient supply, especially on the air supply side. Gas starvation is one of the most serious failure conditions of fuel cells during operation. Therefore, high-precision subsystem control is very important for FPFCV, especially the control of the air supply subsystem.

To improve the dynamic response of the system and prevent system performance degradation, first, the feedforward control is designed to improve the system dynamic in this paper (Fig). Then, the power soft loading strategy based on the loading rate is proposed to avoid air starvation and air compressor surges. Meanwhile, a short-term power prediction-integrated rate strategy (PPS) is investigated. Moreover, the diagonal matrix decoupling strategy based on the above strategy is introduced to achieve decoupling control of air mass flow and pressure.

The results show that the power prediction accuracy is greater than 99% in the 2 s prediction time. It is beneficial to achieve air mass flow and pressure advance control. In UDDS and HWFET conditions, the idling time with PPS can reduced by 15.6% and 7.8%. Note that the idle time and start-stop times can be effectively reduced in PPS in UDDS. Meanwhile, the air mass flow and pressure are decoupled. In terms of total varies (TV), the flow TV of UDDS is effectively reduced from 9.38×10^3 to

2.90×10^3, while the flow TV of HWFET is effectively reduced from 1.03×10^4 to 1.82×10^3, indicating that the flow and pressure changes are stable and the control accuracy can be improved. This can provide theoretical guidance for the design of high-precision air systems for FPFCV.

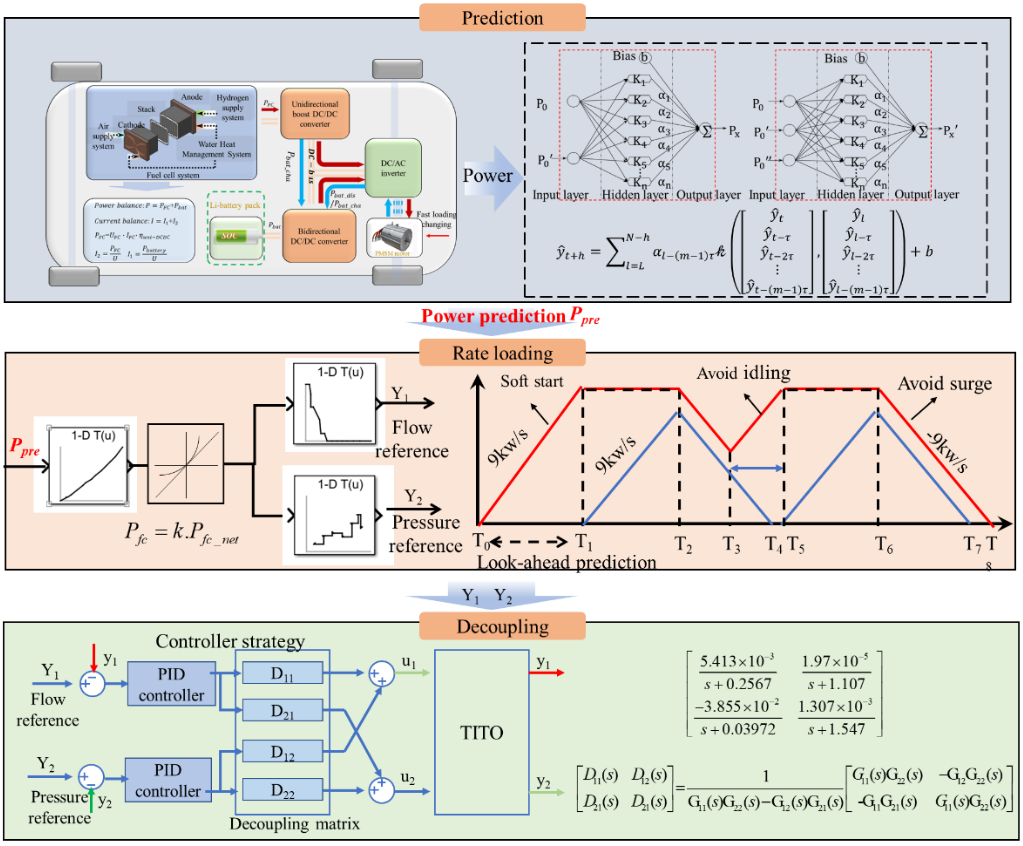

Fig. 1. Power prediction decoupled control design.