Fuel cell and battery hybrid systems for electric vehicles: a comprehensive feasibility analysis

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Abstract:

Electric vehicles (EVs) are gaining popularity as a sustainable and efficient alternative to conventional vehicles. Nevertheless, EVs have drawbacks like a short driving range, a lengthy charging time, and expensive batteries. Fuel cell and battery hybrid systems (FBHS) are promising solutions that can overcome these challenges by combining the advantages of fuel cells and batteries. Fuel cells can provide high energy density, low emissions, and fast refueling, while batteries can provide high power density, fast response, and regenerative braking. However, FBHS require effective power management strategies (PMS) to optimally distribute the power between the fuel cell and the battery according to the load demand and the state of charge. This thesis proposes a novel PMS for FBHS for EVs, based on fuzzy logic and state machine control, and evaluates its effectiveness using standardized driving cycles. The proposed PMS consists of two levels: the first level uses a fuzzy logic controller (FLC) to determine the optimal power split ratio between the fuel cell and the battery, based on the power demand, the battery state of charge, and the fuel cell efficiency; the second level uses a state machine to regulate the power flow of the battery, based on the battery state of charge and the driving cycle. The proposed PMS aims to reduce the stress on the battery, extend the driving range, and enhance the fuel economy of the EV. The performance of the proposed PMS is compared with other existing PMS using different standardized driving cycles, such as the urban dynamometer driving schedule (UDDS), the highway fuel economy driving schedule (HWFET), and the new European driving cycle (NEDC). The results show that the proposed PMS can achieve better performance in terms of battery state of charge, fuel cell efficiency, and hydrogen consumption than the other PMS. The thesis contributes to the feasibility analysis of FBHS for EVs and provides a novel and effective PMS for such systems.