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Studying on the local current density distribution of a proton exchange membrane fuel cell with a dead-ended anode

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The energy efficiency of a proton exchange membrane fuel cell (PEMFC) depends on fuel utilization and operating conditions. In order to increase the fuel utilization, the PEMFC is usually operated with a dead-ended anode. When the anode of the PEMFC is blocked by a solenoid valve, the cell performance gradually decreases with operating time due to accumulation of water and nitrogen diffused from the cathode. When the valve is open, the impurity is purged out of anode, resulting in performance recovery. The impurity is not completely purged out with short purge duration, whereas the fuel utilization is low with long purge duration. Hence, the purge time and duration are two critical issues to study the energy efficiency.

In this study, we developed a mathematical model and conducted experiments to investigate the local current density variation within the active area of a PEMFC with a dead-ended anode. The model can predict distributions of gases and current density along the anode channel. In the experiment, local current density variation was measured by a specially designed single cell. The effect of operating condition of variation and distribution of local current density along the anode channel was studied in the experiment. The experimental data were used to calibrate parameters of the mathematical model.

Experimental results show that local current density gradually decreases at the anode outlet and increases at the anode inlet during the dead-end operation. When the solenoid valve is open, local current density uniformly distributes. The modeling results agree well with experimental data. The results show that nitrogen accumulation rate increases with increasing load current. The model will be used to develop a gas management strategy of PEMFCs.

Keywords: fuel cell; dead-ended anode; energy efficiency; local current density; purge