Development of 1kW Class PEFC Stack System with Variable Gas Flow Channel

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Introduction

Polymer electrolyte fuel cell (PEFC) is considered to the promised candidate of power source for electric vehicle or cogeneration system because of its high energy efficiency. The stable operation of PEFC at the change of load variation has been strongly required for its practical. However, two main problems were observed in the practical operating condition. One is flooding phenomenon at low power operation. The other is large pressure loss by feed gas at high power operation. The former was caused by insufficient gas flow velocity resulting in large cell-voltage-drop. The latter was by the increase of amount of gas flow resulting in the energy loss by power consumption for auxiliary systems such as gas feed pumps. We proposed the variable gas flow channel of which function is to solve these problems simultaneously by changing connections of gas flow channels in series or parallel. The effect of the function on the performance for 1kW class PEFC stack will be discussed in detail.

Experiment

The stack was designed for the nominal output power of 1 kW and was composed of 20 cells. Each cell has gas flow plates and gas diffusion backings on both side of anode and cathode. Representative structure of variable gas flow channel on the plate and gas flow direction for both of series flow and parallel flow were shown in Fig. 1. The each gas flow plate has three manifolds for oxidant and fuel gas. These gas flow channels are switched by the operation of bulbs set on the outside of stack. The cells were assembled with the endplates set on both side of the stack. The evaluation of stack was carried out as described below. The suitable connection of the variable gas flow channels was selected for the operation. Air and reformed gas were humidified at 80 ^{o}C. The composition of the reformed gas was 80% H_2, 20% CO_2, and 10 ppm CO. The utilizations of the fuel gas and oxidant gas were 80% and 40% respectively. Temperature of the stack was controlled at 80 ^{o}C by coolant circulation. The pressure drop was measured between inlet and outlet of gas flow.

Result and discussion

The changes in pressure drop of air and average cell voltage for the 1kW class PEFC stack with series and parallel flow are shown in Fig. 2. The pressure drop of air with series flow is found to be more than 10 kPa at high power operation over 300 mA cm^{-2} caused by longer path of its channel. Furthermore, the big difference of average cell voltage between series and parallel flows at low power operation is observed under 100 mA cm^{-2} caused by the occurrence of flooding phenomenon in the parallel channels. The pressure drop and average cell voltage operated under the optimum selection of the gas flow channels are shown in Fig. 2 (solid line). The stability at wide operating current density from 10 mA cm^{-2} to 600 mA cm^{-2} and small pressure loss below 10 kPa of air are observed by switching the channel from series to parallel between 100 and 200 mA cm^{-2} of current density. The switching connections of the gas flow channels from parallel to series is considered to expel the remained water from its channel to outlet resulting in the stable cell voltage even at low power operation. The switch from series to parallel is also considered to reduce the pressure drop of feed gases by both shortening the length of gas flow pass and doubling the number of the channels resulting in high total energy efficiency by the reduction of energy loss for auxiliary systems at high power operation. Therefore, the PEFC stack with variable gas flow channel will be used for practical power source for electric vehicle or cogeneration system which requires the change of load variation.

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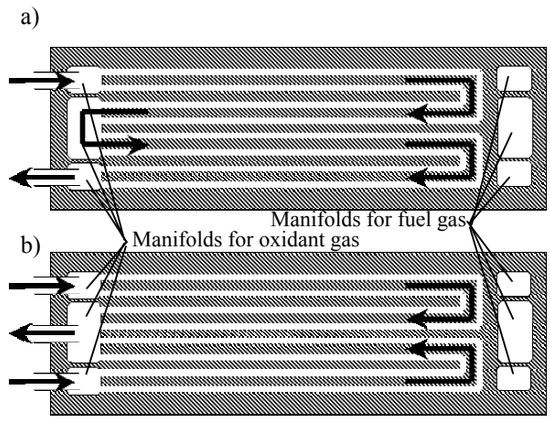

Fig.1 Representative structure of variable gas flow channel on the plate and air flow direction for this function of variable gas flow channel of a) series flow and b) parallel flow.

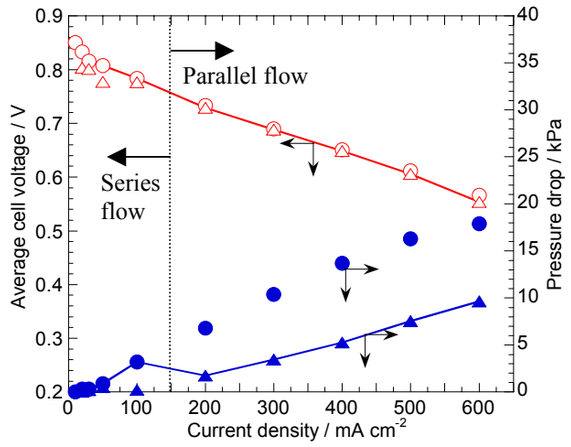

Fig. 2 Change in (●,▲)pressure drop of air and (○, △)average cell voltage for 1kW class PEFC stack operated with (●,○)series flow and (▲,△)parallel flow and optimum selection of the gas flow channels depicted as the solid lines under the condition of air and reformed gas at 80^{o}C.