CELL TO CELL PERFORMANCE VARIATIONS WITHIN A STACK

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Abstract

Variations in cell-to-cell flow rates can result in poor performance or even failure of cells in a fuel cell stack. In this paper, we study cell and stack performance in a planar solid oxide fuel cell (SOFC) stack by considering the variations in cell voltage under various flow distributions. Non-uniform cell voltages may occur due to asymmetry in the boundary conditions (i.e. different anode and cathode inlet flow-rates which influence heat transfer from the electrolyte.) Voltage variations can occur even under uniform flow distribution, but they may increase in magnitude with non-uniform distribution of fuel or oxidizer. Differences in ohmic heating (i.e. due to differences in material resistivities) may also influence the symmetry of the planar cell, which in turn leads to uneven temperature distributions (Figure 1) and voltage variations in a fuel cell stack (Figure 2).

In this study a one-dimensional single cell model was extended to the case of a stack of cells. The present model uses parallel processors in MS-windows environment. The parallelization is based on domain decomposition; each domain consisting of a single cell. This scheme was implemented using message passing interface (MPI) where cell-to-cell communication was achieved via exchange of temperature and thermal fluxes between neighboring cells (Figure 3). The stack was arranged in series so that each cell experienced the same predefined total current. The effective overall resistance of the cells was adjusted to meet the changing voltage condition.

Voltage variations resulting from different flow distributions were analyzed (Table I). Under operating conditions with excess air (oxygen utilization of 19.6%) a fuel cell stack with uniform flow distribution of fuel and oxidizer had as much as 3.6% variation in cell voltage (Figure 2). Results showed that the uniform flow case had the highest stack voltage. Redistributing 20% of the fuel mass flow-rate from the bottom cell to another cell caused as much as 12.0% variation in cell voltage but the stack voltage remained approximately the same.

It can be concluded that the stack voltage and V-I (voltage-current) performance curves do not provide enough insight into the performance of the individual cells in the fuel stack. Distribution of fuel and oxidizer is important when considering design performance. In this regard, the present stack model is a useful design tool enabling parametric study of planar SOFC stacks, along with an assessment of individual cell performance within a stack.

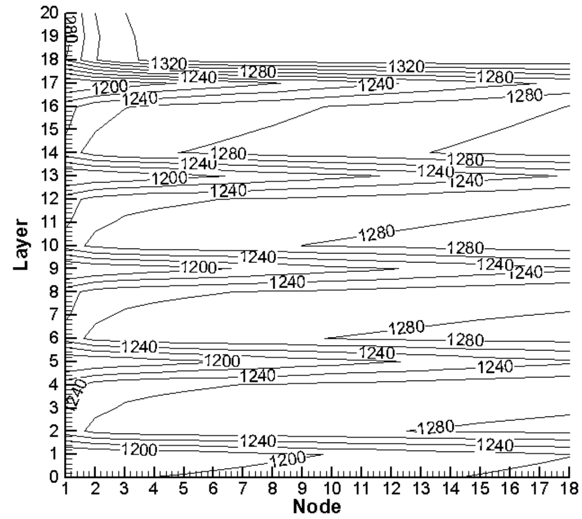

Figure 1 Temperature contours for uniform flow distribution with average total current density = 6666.6 A/m^2

Table I Prescribed anode inlet velocity [m/s] for the six test cases.

	A	B	C	D	E	F
4	0.4070	0.4274	0.4070	0.4070	0.4070	0.4884
3	0.4070	0.4274	0.4070	0.4070	0.4884	0.4070
2	0.4070	0.4274	0.4070	0.4884	0.4070	0.4070
1	0.4070	0.4274	0.4884	0.4070	0.4070	0.4070
0	0.4070	0.3256	0.3256	0.3256	0.3256	0.3256
total	2.0350	2.0350	2.0350	2.0350	2.0350	2.0350

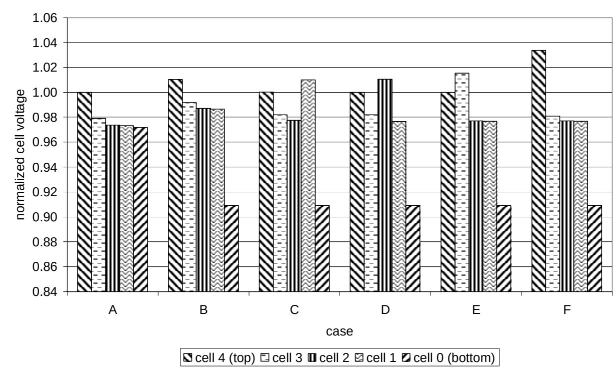

Figure 2 Influence of flow distribution on cell voltage within five-cell stack (with average current density = 6666.6A/m^2).

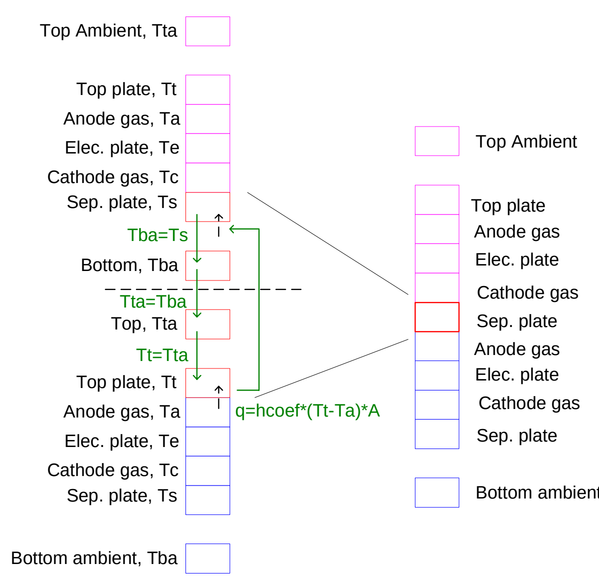

Figure 3 Thermal communications between cells in a two-cell stack.