Seeking minimum entropy production for flow-field patterns and their geometries in fuel cells

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The flow field plates in a fuel cell still have potential for optimization which can lead to an increase in fuel cell performance, one of the targets set by the U.S. Department of Energy. One way to optimize this flow field plate is, to develop a flow pattern, which diminishes the drawbacks from the current industry standards like serpentine and parallel pattern, like non-uniform reactant distribution and water management problems.

For this reason, a tree-shaped flow pattern, inspired by biological transportation networks, was picked, enabling the authors to achieve a uniform distribution of reactants in the fuel cell, increasing its performance [1]. The diameters of the channels in the bifurcations were related by the Murray's law providing minimal entropy production [2]. In this work we varied the width and depth of the flow channels, and the number of generations was determined by the Peclet number providing the diffusion transport in the gas diffusion layer. The energy loss due to the T-shape bifurcations and non-laminar entrance flow in each channel were accounted for. Both 1D and 3D computations of the pressures and velocities in the channels has been used for detailed calculations of the energy dissipation due to viscous and hydraulic losses in the flow field plate. The optimal design was determined from the observation that certain units with optimal efficiency have a uniform distribution of entropy production [2,3]. The best designs with constant and gradually diminishing depth of the consequent channels were compared to the classical serpentine design and proposed for improvement of the fuel cell efficiency.

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