Optimization Model for Bio-Inspired Design of Bipolar Plate Flow Fields for Polymer Electrolyte Membrane Fuel Cells

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ABSTRACT
The flow field of a bipolar plate distributes hydrogen and oxygen for polymer electrolyte membrane (PEM) fuel cells and removes the produced water from the fuel cells. It greatly influences the performance of fuel cells, especially regarding reduction of mass transport loss. Flow fields with good reactant distribution capability reduce the mass transport loss, thus allowing higher power density. The research described in the present paper is inspired by natural structures such as veins in tree leaves and blood vessels in lungs, which efficiently feed nutrition from one central source to large areas and are capable of removing undesirable by-products. A mathematical model is developed to optimize the flow field with minimal pressure drop, lowest energy dissipation, and uniform mass distribution. The model can be used to generate optimum flow field designs, leading to better fuel cell performance for different sizes and shapes of bipolar plates. Finite element modeling (FEM) based simulation of PEM fuel cells is conducted to compare the flow field designs obtained using the developed optimization model and the conventional designs. The numerical results show that the fuel cell with the optimized design has a higher power density than that of the conventional designs, with a lower pressure drop and more uniform transport of the reactants.