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VUB Technology Offer - CHIS

CFD model for improved flow field designs in fuel cells

Maldistributions reducing performance and life time of fuel cells

The distribution of species concentrations in a fuel cell due to local consumption of fuel and local transport of water through the membrane causes **maldistributions in current density, temperature, and water concentration in three dimensions.** This causes **flooding or drying of the membrane, shortens the life time of the MEA (Membrane Electrode Assembly) and results in lower catalyst utilization.** Changing the cell's flow field design can minimize these stresses and result in optimal catalyst utilization.
The Chemical Engineering Department (CHIS) of the Vrije Universiteit Brussel (VUB) offers a new solution to answer this need.

Keywords

fuel cell efficiency
design
CFD model
flow field structure
field maldistribution
life duration

Technology description

Currently planar fuel cell designs are often designed with one of three basic flow field structures: parallel, serpentine, or grid (Table 1). Parallel and grid designs usually provide low pressure drop, and serpentine designs usually give high fuel cell performance.
However, lots of drawbacks are associated according to the type of design, amongst which the formation of stagnant areas caused by preferential flow (for parallel and grid designs) and substantial pressure drops caused by long reactant flow paths (for serpentine designs). Any reactant concentration decreases lead to considerable Nernst losses and **non-uniform current density distribution,** reducing both the performance and the lifetime of PEM (Polymer Electrolyte Membrane) fuel cells.
Development of alternative flow field designs that exhibit better distribution characteristics is of great importance to optimize cell efficiency and life duration.

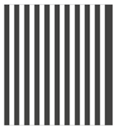
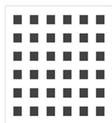
Flow field designs	Parallel	Serpentine	Grid	N1	N2
Schematic flow design				N1	N2
Velocity variation distribution	1.26	0.86	1.02	1.06	1.07
Current variation distribution	1.72	2.24	0.94	0.33	0.33

Table 1:

Comparison of different flow field designs. Conventional designs (parallel, Serpentine, and grid) and newly developed designs with improved performance (N1 and N2). The current and velocity maldistribution coefficients were achieved at potentiostatic operation mode (Ecell) of 0.2 V.

The **three-dimensional computational fluid dynamic model (CFD)** allows the testing of different flow field designs. Up to now, 2 designs have been identified that show large improvements in terms of performance and pressure drop.

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CFD model leads to improved designs

The CFD model describes the distribution of velocity, current and reactant and product concentrations on the cathode side of the fuel cell (Fig. 1). This model is developed in Fluent® and the evaluation of alternative flow field designs is very straightforward.

The quantitative characteristic of field maldistribution for current, reactant concentration and velocity are presented by variation coefficients. Higher variation coefficients indicate higher field maldistribution. The simulation results indicate a non-uniform distribution of velocity and local current density in conventional cathodes with parallel, serpentine and grid flow field designs, as indicated in Table 1. The simulation results for the **new designs N1 and N2** indicate an enhanced fuel cell performance caused by decreasing the maldistribution of fields.

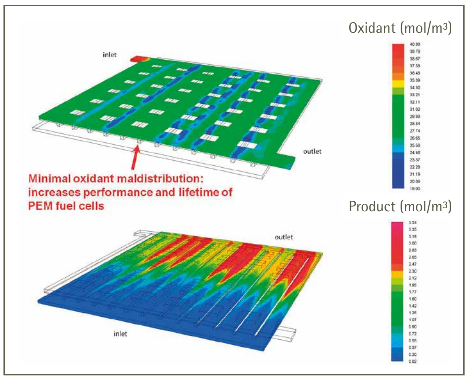

Figure 1:

3D concentration profiles of fuel and oxidant in a fuel cell reactor with grid flow field designs. The profile of oxidant leads to the conclusion that a design that generates a more uniform distribution of oxidant results in higher cell performance.

Advantages

- Improved efficiency due to mass transfer intensification
- Higher production of chemicals due to the improved performance

Market opportunities

- Production of improved bipolar plates or fuel cells with higher overall fuel cell performance
- Accelerating development of new and better flow field designs (intelligent design)

Commercialization possibilities

Both the new and improved designs, or the CFD model itself can be licensed.

Interested parties can contact

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