Dependence of the Current Density Distribution with Flow Channel Geometry in a Half-cell Model

Otávio Beruski[1], Joelma Perez[1]

1. Institute of Chemistry of São Carlos, Av. Trabalhador São-carlense, 400, São Carlos, São Paulo, Brazil.

Introduction: Possessing a working computational model for a device allows one to correlate between available experimental results and fundamental properties and quantities of the system. This proves to be particularly useful in the case of fuel cells, where the scarce availability of experimental data is well known.

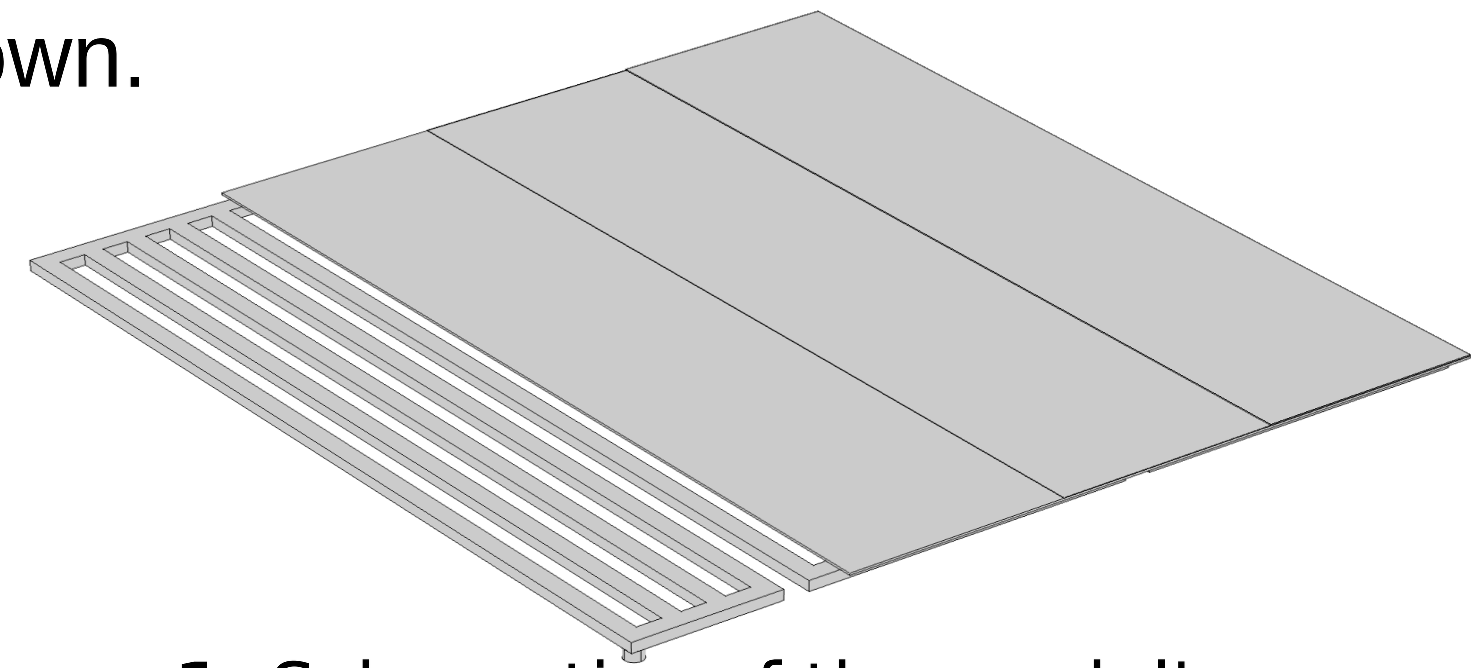

Figure 1. Schematics of the model's geometry.

Computational Methods: The present approach uses the following physics interfaces, in an attempt to model the stationary state of the cathodic half of a PEMFC (Figure 1): Free and Porous Media Flow, Transport of Concentrated Species, Heat Transfer in Porous Media and Secondary Current Distribution.

Under the assumption that the anodic processes aren't limiting, an electrolyte-electrode boundary condition is used to model such processes. The parameters and flow channel geometries where obtained elsewhere [1], when available, or from examples in COMSOL's Model Gallery.

Results: The present results are mainly qualitative, however, they reproduce the main features observed in the experimental work it intends to simulate [1], namely the current density distribution in the mass transport polarization regime, shown in Figure 2. Figures 3 and 4 shows the flow field pressure and speed, respectively.

One can observe that the current distribution seems to correlate to different quantities, depending on the flow channel geometry.

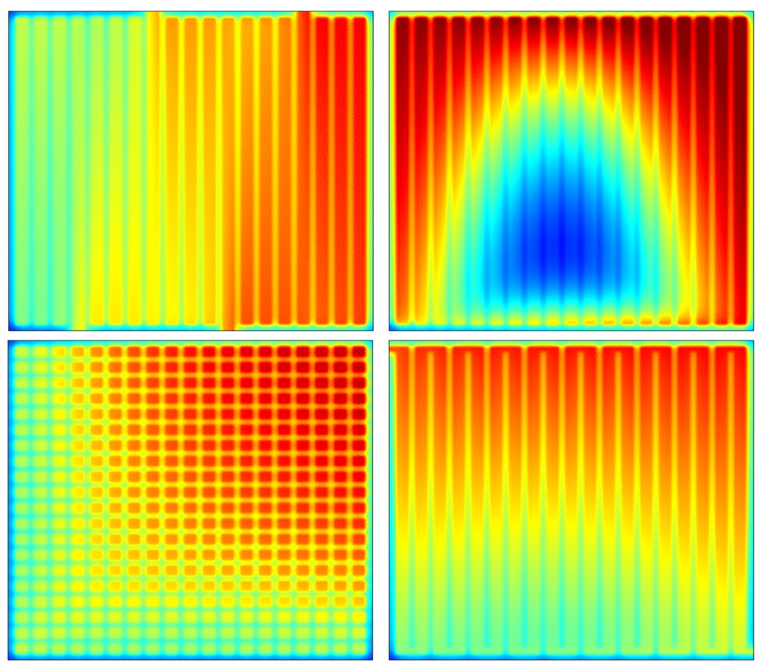

Figure 2. Local current density distribution.

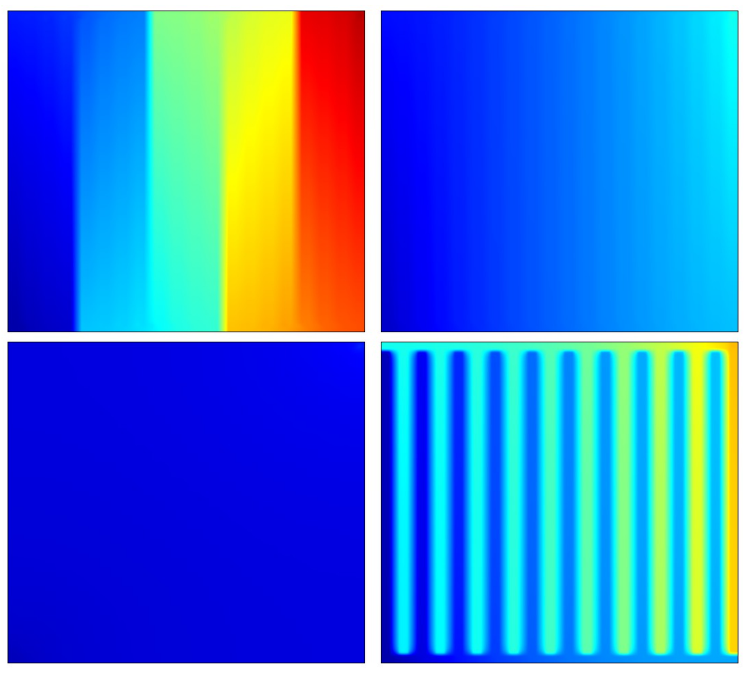

Figure 3. Flow field Pressure.

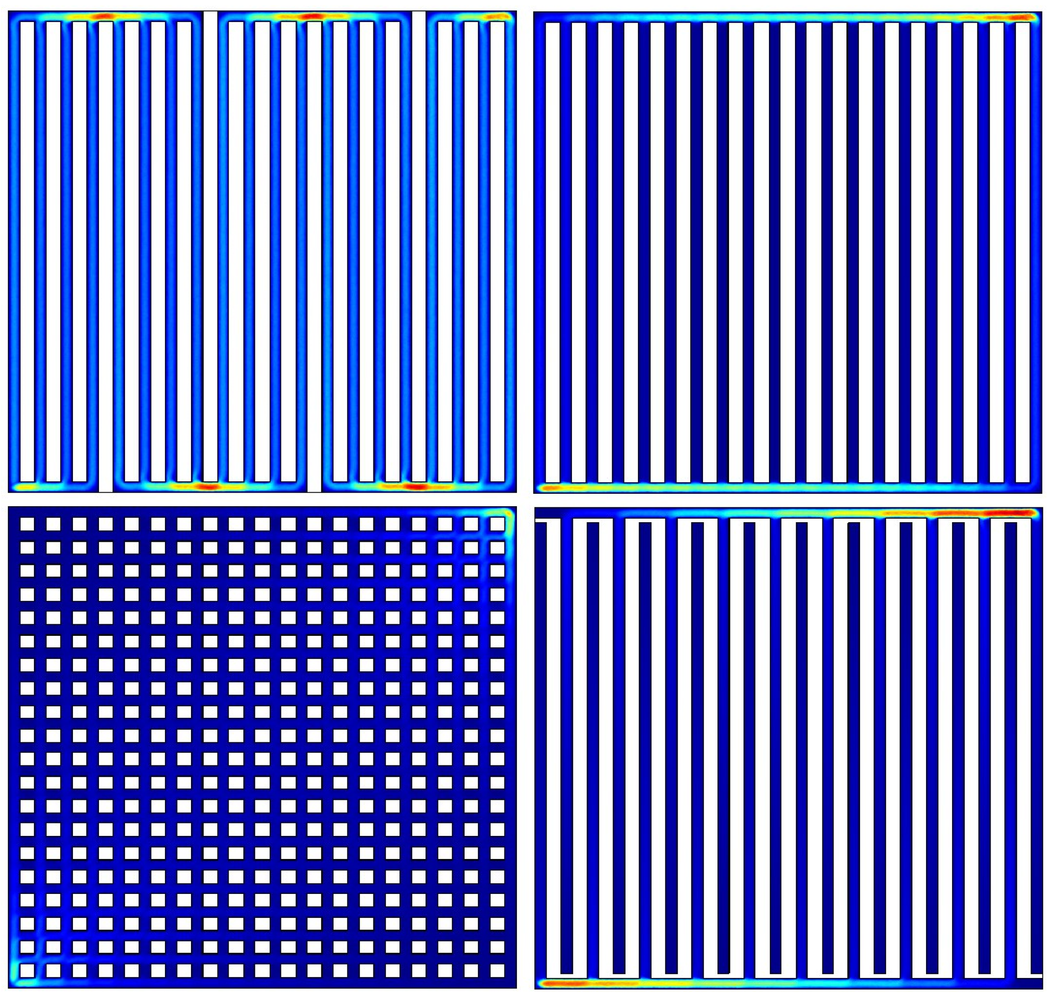

Figure 4. Flow field speed.

Conclusions: It can be seen that, depending on the flow channel geometry, the limiting variable seems to change. Such information is difficult to obtain experimentally, but is easily simulated. This correlation is important during optimization of the operational conditions, suggesting which conditions lead to the best response of the device.

Reference:

1. Justo Lobato et. al., J. Power Sources, 196, 4209-4217 (2011).

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