EFMC11 Seville, Sept.12-16, 2016 SPAIN
11th European Fluid Mechanics Conference

FLUID MECHANICS CONSIDERATIONS FOR THE OPTIMAL DESIGN OF PEMFC STACKS

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Fluid mechanics considerations are essential to ensure a homogeneous distribution of reactant gases in all the cells in a stack and over the catalytic surfaces in each cell. This requires a proper design of the stack manifold and the flowfield geometries for both monopolar and bipolar plates. Considering the flow in bipolar plates, in general, uniform velocity and pressure fields are desired so that hydrogen and oxygen homogeneously reach all the points in the membrane-electrode assembly. To achieve this objective, the topology of the plate channels has to be designed minimizing pressure losses. In the case of complete stacks, it is important to be sure that all the cells receive the same flow of gases to avoid misbalances and flow starvation that can finally result in potential inversion of the cells. Basic fluid mechanics equations can be applied to estimate the pressure losses in any specific flowfield geometry for plates, and in the reactant gases manifold. Numerical simulations can provide accurate predictions of the velocity and pressure fields. They can be compared with experimental measurements of the velocity at the different channels and the overall pressure losses either in a single cell or in the complete stack.

Similarly, fluid mechanics equations can also be used to properly design the air cooling system for the required thermal management of PEMFC stacks. Developed models should include electrochemical, mass, and heat transfer equations. By minimizing both the total pressure drop and the power consumption of the air-fan system, the air-cooling system design can be optimized, including the number of cooling channels and their cross-section geometry, and the selection of the air-fans.

This paper discusses all these concepts and presents numerical and experimental examples applied both to the design of the gas distribution system in bipolar plates and complete stacks, and the optimal design of air cooling systems.