

NUMERICAL MODEL OF PEM TYPE FUEL CELL WITH BIPOLAR PLATES PRODUCED BY STAMPING OF THE COMPOSITE COATED STEEL SHEETS

Hala M., Kodým R., Prokop M., Paidar M., Bouzek K.

Department of Inorganic Technology, University of Chemistry and Technology, Prague, Technická 5, 166 28 Prague 6, Czech Republic

Bipolar plates (BPs) are an important part of a low-temperature PEM fuel cell (FC). Currently, BPs are mainly made of graphite or polymer-carbon composites. The promising alternative represents metallic BPs. They are characterised by high electrical conductivity and mechanical strength allowing low-weight cells/stacks to be produced. At the same time, they are suitable for mass production. However, metallic BPs are susceptible to corrosion. Their corrosion stability can be improved by applying a suitable protective surface coating. The coatings used today are typically based on expensive materials, making this approach economically unviable. Structured composite polymer films represent a promising alternative due to their cost effectiveness and easy production. This study focuses on the development of metallic and polymer coated BPs by means of numerical modelling.

A multiscale modelling approach was chosen to simulate mass and charge transport in a single FC with stamped parallel flow-field channels. A macrohomogeneous 3D model was proposed and implemented accounting for fluid and charge flow, electrode reactions kinetics, and multicomponent mass transport. The Navier-Stokes equation is used to describe fluid flow. The electrochemical kinetic parameters were determined experimentally by means of a specially designed FC suitable for rapid in-operando characterisation of the developed coatings. A simplified 1D model developed for this purpose was used to fit the obtained experimental data. Multicomponent mass transport is described by Stefan-Maxwell equations.

An important feature of the 3D FC model represents the possibility of varying flow channel geometry parametrically. This allows to study the role of the channel geometry in the current density, components partial pressures, and other quantities local distribution. The numerical model developed thus opens a way to a smart and effective design of the BPs geometry. Together with the development of innovative coatings, this leads to cost-effective and easily manufacturable BPs allowing commercialization of PEM FCs.

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