Sensitivity analysis of a stationary, macro-homogeneous, 1D through-plane membrane electrode assembly model for PEMFC

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A stationary, macro-homogeneous 1D through-plane model of a membrane electrode assembly (MEA) has been developed by Vetter and Schumacher [1]. In this work, a sensitivity analysis for various parameters of this MEA model is carried out. 48 parameters are identified that impact the model behaviour through the parameterization of transport properties, electrochemistry and through operating conditions. All parameters have been varied over a decade and compared to the initial value to study the impact on the simulated I-V characteristic. If the variation outranged physically reasonable limits, the latter are applied as variation boundaries.

In Figure 1 the variation of the electrical conductivity of the GDL σ_e is shown as exemplary simulation result. The value is varied between 130 and 1300 S/m to account for data of different products types, e.g. from SGL Carbon [2], Toray [3], Freudenberg [4] and Ballard [5]. Fig.1 (a) depicts the polarisation curve with cell voltage U in V plotted over the current density i in A/cm². Two reference points at static cell voltages of U_{ref} = 0.8 V with i_{ref} = 0.3 A/cm² (partial load) and U_{ref} = 0.6 V with i_{ref} = 2.3 A/cm² (full load) are used in order to evaluate the specific parameter sensitivity. The colour legend depicts the varied parameter values. It can be seen that a higher electrical conductivity leads to a higher current density at equal cell voltage. In Fig.1 (b), the relative deviation of the current density at static cell voltage $CCD = (i\text{-}i_{ref})/i_{ref}$ is plotted over the varied parameter range. Passing the 0-line indicates passing the default parameter value. Thus, positive deviation stands for an increase and negative deviation for a decrease in performance. The relative deviation at 0.6 V reaches from -0.1 to 0.2, indicating a high sensitivity of the model to σ_e at full load operation. For partial load conditions, the influence of σ_e is lower than at full load, as expected from the domination of activation losses over ohmic losses at low current densities.

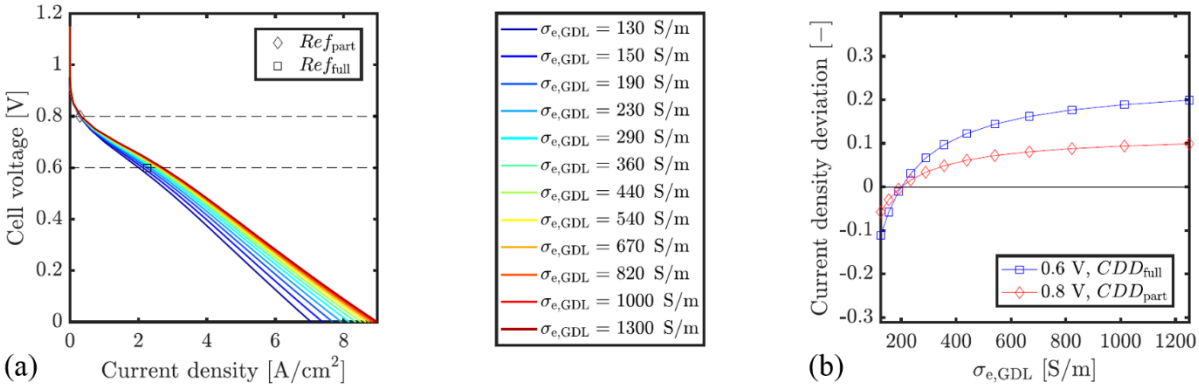

Figure 1: Sensitivity of the electrical conductivity σ_e at temperature T = 65 °C, pressure p = 2.2 bar and relative humidity RH = 0.95 at the anode and 0.9 at the cathode. The diagrams show the polarization curve (a) and the current density deviation (b). A diamond (◊) indicates the reference simulation at partial load (0.8 V) and a square (□) denotes the reference simulation at full load (0.6 V). An increase in σ_e leads to a performance gain.

References:

1. R. Vetter, J. O. Schumacher. *Free open reference implementation of a two-phase PEM fuel cell model*. Manuscript in preparation for Computer Physics Communications
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