POSITIONING THE REFERENCE ELECTRODE IN POLYMER EXCHANGE MEMBRANE FUEL CELLS (PEMFC): CALCULATIONS OF PRIMARY AND SECONDARY CURRENT DISTRIBUTION

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INTRODUCTION

Polymer exchange membrane fuel cells (PEMFC) consist of a proton conducting membrane, sandwiched between two platinum impregnated porous electrodes. Unlike aqueous electrochemical systems, the reference electrode has to be placed somewhere outside the region between the PEFC electrodes. For a typical thickness of the membrane (25-100µm), the alignment of anode and cathode significantly affects the polarization on the electrodes as measured with a reference electrode [1]. Therefore, it is necessary to carefully consider the placement of the reference electrode, to ensure that the correct polarization is measured.

THEORY AND APPROACH

When concentration gradients in the electrolyte can be neglected, the current density can be expressed as: $i = -\kappa\nabla\Phi$, and the potential satisfies Laplace's equation. The boundary condition at all insulating surfaces is $\partial\Phi/\partial n = 0$ where n is the dimension normal to the surface. On the electrode surfaces, the boundary condition is: $\eta = V - \Phi$, where *V* is the potential of the metal electrode. For the case of a primary current distribution, η=0. For the secondary current distribution, the Butler-Volmer equation describes the relation between the overpotential and the current:

$$i = i_0[\exp(\alpha_a F\eta/RT) - \exp(\alpha_c F\eta/RT)]$$

The Butler-Volmer relation is linearized using either the linear or Tafel approximations, and Wagner numbers for each case are defined.

For this system, we solve Laplace's equation by a finite volume method. Numerical calculations were performed with the commercial CFD software package: CFD-ACE+. Modifications to CFD-ACE+ necessary for these calculations will be described.

RESULTS AND DISCUSSION

Fig. 1 shows the effect of the geometry on the polarization for the primary current distribution. When one electrode is larger than the other by 1.5 times the electrolyte thickness, the oversized electrode has an overwhelming effect on the uniform potential region between the electrodes. The potential of that region is equal to that of the oversized electrode. Therefore, the reference electrode should be put in this region and it measures the potential difference to the oversized electrode.

Fig.2 is an example of a hydrogen/air PEMFC (secondary distribution), and the anode is larger than the cathode by 1.5 times the membrane thickness. At 1.5 times the membrane thickness beyond the edge of the anode, the potential is uniform and equal to that of the anode. Therefore, if the reference electrode is put in this region it will measure the potential adjacent to the anode. The situation is more complex if the cathode is the oversized electrode.

CONCLUSIONS

The study indicates the geometry of a PEMFC has a direct relation to the measured electrode polarization, thus making the positioning of the reference electrode critical. During this study, the effect of geometric factors on the measured electrode polarization has been investigated and suggestions on the position of the reference electrode and cell design have been given.

ACKNOWLEDGMENT

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REFERENCES

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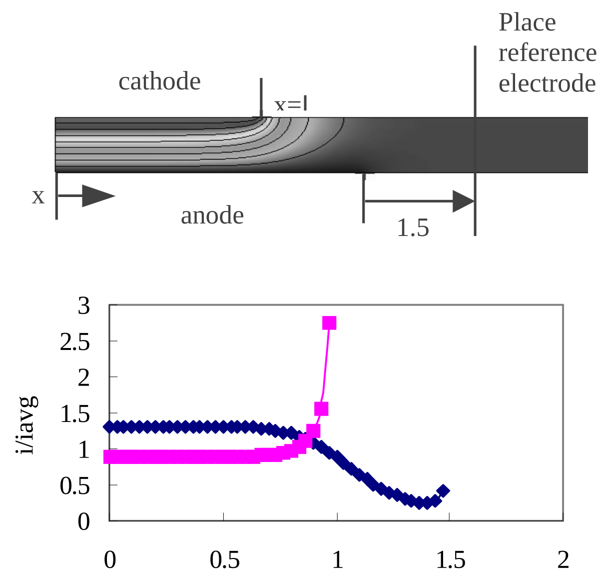

Fig.1: Primary current distribution oversize/electrolyte thickness= 1.5.

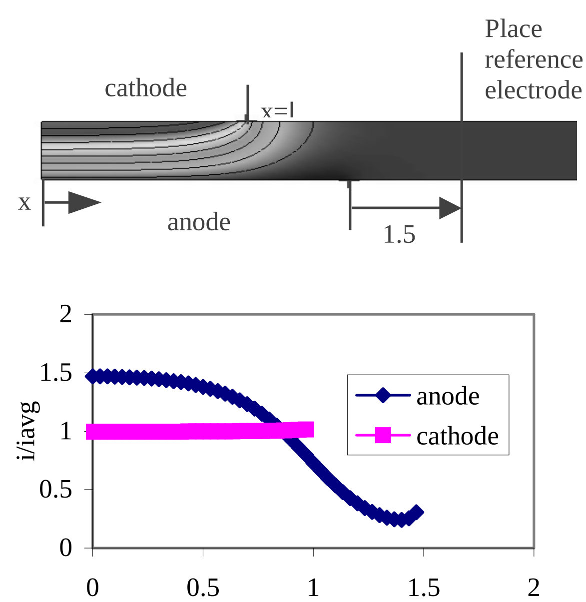

Fig.2: Hydrogen/air PEFC example with Wa(anode)=0.1, Wa(cathode)=25