IPID4all Doctorate Research Exchange with University of Oldenburg
Feedback report

Marc Secanell, PhD

Energy Systems Design Laboratory
(http://www.esdlab.mece.ualberta.ca/)
Department of Mechanical Engineering
University of Alberta
10-358 Donadeo Innovation Centre for Engineering,
9211-116 Street NW,
Edmonton, AB, Canada T6G 1H9
Phone: (780) 490 8808 (cell)
(780) 492-6961 (office)
E-mail: secanell@ualberta.ca

Dr. Peter Wagner

NEXT Energy
(www.next-energy.de)
EWE-Forschungszentrum für Energietechnologie e. V.
at the University of Oldenburg
Carl-von-Ossietzky-Straße 15
D-26129 Oldenburg
Germany
Tel.: +49 441 99906-316
Fax: +49 441 99906-109
E-Mail: peter.wagner@next-energy.de

Duration stay: May 10-13, 2016

Re: Polymer electrolyte fuel cell characterization, testing and numerical analysis

Introduction

I am an associate professor at the University of Alberta working in the areas of: a) analysis and computational design of electrochemical energy systems, such as polymer electrolyte fuel cells, and polymer electrolyzers, b) fabrication and characterization of polymer electrolyte fuel cells and electrolyzers, c) cooling tower analysis and design, and d) flywheel fabrication, analysis and design optimization. My current research activities in the area of fuel cells include the development of the open-source Fuel Cell Simulation Toolbox (OpenFCST), an open-source framework to analyse and design fuel cells (see www.openfcst.org). My group is also working on the fabrication and characterization of low loading polymer electrolyte fuel cells. Low loading electrodes are manufactured using inkjet printing technology in order to achieve accurate control of the deposition thereby allowing my group to fabricate low and conventional electrodes as well as patterned electrodes.

The aim of my visit to NEXT ENERGY was to establish a fruitful collaboration in the area of polymer electrolyte fuel cell numerical modelling, fabrication and characterization with NEXT ENERGY and the University of Oldenburg. This collaboration would include the joint development of OpenFCST, an open-source fuel cell program developed at the University of Alberta, to extend its capabilities to include the analysis of high temperature polymer electrolyte membrane fuel cells (HT-PEM), a core area of research at NEXT ENERGY. Possible additional collaborations could include the study of inkjet printing as a manufacturing method for high temperature electrodes, and the use of the characterization tools developed at the UofA to further understand transport in the materials used for high temperature fuel cells developed at NEXT ENERGY. Collaboration would include short visits, up to 3 months, of students and researchers for both contributing organizations.

Research Undertaken

I spent three days at NEXT ENERGY. During this time, I toured the facilities and learned about the imaging, synthesis, characterization and testing tools at NEXT ENERGY. I also meet Dr. Alexander Dyck and Dr. Peter Wagner and exchange information with the researchers in their laboratories.

The second day of my visit, I also delivered a seminar introducing the main experimental and numerical activities in my research group. These included fabrication and characterization techniques

used, analysis of low-loading fuel cell electrodes, and introduction to the main capabilities of OpenFCST, the open-source fuel cell numerical modelling framework developed at the University of Alberta.

Based on our discussions, a collaborative plan was developed to extend OpenFCST to high temperature fuel cells, assess the potential for inkjet printing for fabrication of high temperature fuel cell catalyst coated membranes, and to design a framework for graduate student visits within the IPID4all DAAD program.

The following three main target areas were identified:

- Study of crack formation during testing in LT-PEM inkjet printed and doctor blade MEAs
    - Goal: To study the structure of the MEAs fabricated in the ESDLab at beginning of life and after testing (end of life) in order to study delamination and crack formation in the CL and MPL
    - Methodology: ESDLab to prepare three 25 cm^2 MEAs by inkjet and doctor blade, as well as conditioning and testing protocol. NEXT ENERGY will use one of the MEAs for imaging the structure at beginning of life, and another one for testing and then imaging at end of life. (One extra MEA as backup)
    - Expected outcome: Determine if the fabrication method used prevents the development of cracks during testing. Better understanding of inkjet printed electrode degradation.
- HT-PEM CCMs:
    - Goal: Assess the feasibility of fabricating HT-PEM CCMs by inkjet printing
    - Methodology: Use the PBI membrane (not doped) that Peter gave me at NEXT ENERGY as a substrate. Print a 25 cm CL with 40%wt Pt/C catalyst to a loading of about 0.2 mg/cm2 with 20%wt Nafion in both anode and cathode. Send to NEXT ENERGY to assess performance
    - Expected outcome: Assess the feasibility of using CCMs for HT-PEM.
- Modelling of HT-PEM:
    - Goal: Develop a HT-PEM model in OpenFCST
    - Methodology: Gas transport, reactions, etc. models are already developed. The main goal will be to develop a model for proton transport in PBI membranes and for phosphoric acid migration inside the MEA. NEXT ENERGY would provide experimental data.
    - Expected outcome: Extend OpenFCST to HT-PEM. Use OpenFCST to provide insight on the optimal operating conditions and composition of HT-PEM electrodes.

Personal Experience

The visit to NextEnergy was very helpful and informative, and it allowed me to be able to create the future plan above for collaborations. The lab tours and discussions with Dr. Peter Wagner and his team allowed me to get a very good idea of the equipment, expertise and resources available at NEXT ENERGY and, through discussions with them, allowed us to define attainable collaborative research areas of mutual interest. I believe the visit was of paramount importance to get a general idea of the research and capabilities.

During the seminar and after the seminar, I had the opportunity to show the equipment and expertise in my laboratory and, afterwards spend time talking to the graduate students working at NEXT ENERGY. The interaction with graduate students allowed me to discuss possible student exchange project and give them an overview of what to expect at the University of Alberta and in my

research team. These interactions I think were paramount to attracting graduate students to work on the three areas of collaboration above. Proof of the benefit of these interactions is that Khrystyna Yezerska is likely to apply for a IPID4all doctoral research exchange in the next call.

Conclusions

I believe the IPID4all program is one of the best programs in the world to increase international collaborations. Having the opportunity to spend three days at NEXT ENERGY touring the facilities and talking to researchers in their own lab gave me a very unique perspective that I do not think I could have achieve through teleconferencing. I think the visit set the foundation for further collaboration between our research institutions. I hope Canada would have a similar program.

Outlook

As discussed in section “Research Undertaken” three areas of collaboration have been identified. My group is keen on working in these three areas with NextEnergy. Thus far, I have received the necessary materials to tackle goals 1 and 2, and we are in the process of fabricating the electrodes to be sent to NextEnergy. Regarding goal 3, a PhD student at NextEnergy, Khrystyna Yezerska, has already started to work with OpenFCST and is likely to visit the University of Alberta in 2017 so we can help her develop the necessary extensions to OpenFCST to simulate HT-PEM

DAAD

Federal Ministry
of Education
and Research