2011-2012

Graduate Seminar Series

The Department of
Mechanical Engineering – Engineering Mechanics

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Dr. Jon Pharoah
Associate Director -RMC Fuel Cell Research Centre
Queen's University, Kingston, Ontario, Canada

Dr. Jon Pharoah is an Associate Professor of Mechanical and Materials Engineering at Queen's University. Since 2005, he has served as the Associate Director of Queen's-RMC Fuel Cell Research Centre that he co-founded. Starting 2002, his contributions to the field of fuel cells modeling and experiments have resulted in about 30 *journal articles* with average of 12.6 citations and an H-index of 10. His research in the area of fuel cells has focused on understanding the complex interaction between fuel cell components and between scales spanning from the nano scale in the electrodes to the scale of full cells and stacks.

This work takes full advantage of state of the art multi-scale modeling techniques coupled with novel experimentation. Key research interests in PEM fuel cells include: development of durable, ultra low Pt catalysts, understanding thermal effects and understanding the role of liquid water in PEM operation. Dr. Pharoah's contributions have resulted in significant research efforts with leading fuel cell companies, and in invitations to provide invited lectures both in industry (Adam Opel, Germany, Ballard Power Systems, Canada) and University (NTNU, Norway, IIT-Bombay, India, University of Victoria, Canada). He has also been an invited researcher at the Norwegian Academy of Sciences, has been invited to teach short courses in fuel cells both internationally and in Canada and to contribute book chapters on the subject.

Thursday, Mar. 15, 2012 4:00 – 5:00 p.m. Room 112, ME-EM Bldg.

Fuel Cells and Renewable Energy ... and Multi-Scale Modelling of Solid Oxide Fuel Cells

Fuel cells of various types are firmly in the initial stages of commercialization. Phosphoric acid fuel cells have been deployed in the 250 kW range in a vast array of stationary power applications. Molten carbonate fuel cells have also been deployed in capacities from 250 kW to several MW and are fueled by either natural gas or bio gas. Solid oxide fuel cells have been deployed, again for stationary power in the 100 kW size and commercial products have demonstrated AC efficiencies in excess of 60% fueled on natural gas in units as small as 1 kW. Polymer electrolyte fuel cells have also been deployed up to capacities of 1 MW for stationary power. For mobility applications, most leading automotive companies are very close to commercial fuel cell vehicles, and virtually all of them claim that fuel cells are the only technology that can replace existing vehicles with zero emissions and the same functionality. The same fuel cells are operating in the entire fleet of transit buses in the city of Whistler, Canada, where they were introduced for the 2010 winter olympics. Smaller versions of the same fuel cells are continuing to replace lead acid batteries in forklift trucks for distribution centres, and the technology has been clearly demonstrated to give twice the talk time on a mobile phone compared to the current lithium ion battery pack. It is clear that fuel cells are well on their way to commercialization and they will continue to succeed due to their very high efficiencies and zero to low emissions. Fuel cells are also major enablers for the large scale implementation of renewable energy.

Most types of fuel cells can be fueled with hydrogen, while some types require hydrogen as a fuel. Hydrogen is an ideal fuel in the sense that it can be produced from many different sources and pathways can be produced locally virtually anywhere results in noemissions at the point of use and is typically used at very high efficiency. It can be reformed from fossil fuels (with corresponding emissions of carbon dioxide), or it can be produced through the electrolysis of water using any available source of electricity. It can be used for remote electricity applications, grid energy applications and as a transportation fuel. The versatility of hydrogen open up several important possibilities for renewable energy systems as well as for utility companies.

Conventional renewable energy is predominantly either wind or solar, both if which suffer from severe intermittency and a lack of predictability. When the penetration of these technologies is small, this is not a problem since the electricity grid can absorb the power when it is available and it is not overly missed when it is not. As the level of penetration exceeds around 10% of the energy mix, major problems begin to arise and typically energy grids become more costly to run and often have higher emissions. Fuel cells offer a way to increase the penetration while potentially reducing the cost of the system and certainly the emissions. When excess electricity is available from renewables, hydrogen can be produced and stored and when electricity is needed, this hydrogen can be used to generate electricity. Very few technologies have this general capability on the scale that is needed for grid storage. Hydrogen, however can also be used as chemical fuel or feed, which opens up enormous opportunities for utilities.

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