

Mechanical Engineering Department Seminar

The Development and Testing of Solid Oxide Electrolyzer Cells

Dr. J. Stephen Herring

Idaho National Laboratory

A team at the Idaho National Laboratory and Ceramatec, Inc. in Salt Lake City has been developing solid-oxide cells for the efficient High Temperature Electrolytic (HTE) production of hydrogen using the heat and electricity of advanced nuclear reactors. This team, which also includes participation by Argonne National Laboratory, MIT and UNLV, has been conducting experiments at progressively larger sizes and longer durations to build on the technology developed for solid-oxide fuel cells and to investigate the technical challenges unique to electrolytic operation.

By operating at temperatures of 800-850 °C, the cell voltage of the electrolyzer can be reduced by about 40% from the room temperature voltage and the reaction rates are much faster at the high temperatures. The planar cells are electrolyte-supported and consist of 0.150 mm-thick yttria- or scandia-stabilized zirconia. The inlet to the cells is 90 v/o steam, 10 v/o hydrogen, while the outlet is about 25 v/o steam and 75 v/o hydrogen. The hydrogen in the inlet is needed to maintain reducing conditions on the nickel-cermet electrode.

In addition to producing hydrogen, we have been conducting a series of experiments in which the O²⁻ ion-conducting electrolytes can be used for the co-electrolysis of CO₂ as well as H₂O. The resulting CO + 2 H₂ mixture ("synthesis gas") can serve as feedstock in the Fischer-Tropsch reaction for the formation of liquid fuels, such as gasoline, diesel and jet fuel and of synthetic lubricating oils. This process is potentially a direct application of nuclear energy to the production of synthetic fuels very similar to the conventional transportation fuels we now use.

In our most recent work, a three-module HTE Integrated Laboratory Scale (ILS) experiment started operation on Friday morning, September 5, 2008. After a gradual heat-up, the three modules began producing hydrogen (H₂) at a rate of 0.504 kg H₂/hr (5.65 Normal (N)m³/hr). This experiment also included the trial of heat recuperation and hydrogen recycle. The heat recuperators allowed the output temperature of the steam and air superheaters to be reduced from approx. 800 °C to about 400 °C, thus reducing the temperature of the baseplate of the hot zone and the overall strain on the system. Later that morning, hydrogen recycle was established, in which approx. 15-20% of the total hydrogen output stream was pumped back into the inlet for the three modules. HTE requires about 10% (volume) of hydrogen at the inlet of the modules in order to maintain a reducing atmosphere through the cells. Previously, this hydrogen was provided using hydrogen cylinders. With the use of hydrogen recycle in this experiment, the use of bottled hydrogen was completely avoided (except during startup). At 0.504 kg hydrogen per hour, this ILS experiment is the largest experiment in the world for the high temperature electrolysis of steam.

Dr. J. Stephen Herring is an Idaho National Laboratory Fellow and the Technical Director for High Temperature Electrolysis in the DOE Office of Nuclear Energy's Nuclear Hydrogen Initiative. He is responsible for the development of solid oxide cells for the efficient production of hydrogen and synthetic fuels using the heat and electricity from advanced nuclear reactors. He has been active in the reactor physics analyses of nuclear fuels for the consumption of long-lived wastes and development of other advanced energy sources at the INL since 1979.

Dr. Herring holds BS degrees in mechanical and electrical engineering from Iowa State University (1971), and a PhD in nuclear engineering from the Massachusetts Institute of Technology in 1979. He was also a Rotary Foundation Fellow at the Eidgenössische Technische Hochschule in Zürich, 1974-75, and a Visiting Scientist at the Kernforschungszentrum Karlsruhe in 1987.

Host: Prof. Frank Chen

Everyone is welcome to attend. All Mechanical Engineering graduate students are required to attend the seminar. Light refreshments will be served.

Wednesday, October 8, 2008

3:45 PM, Room B213, 300 Main Street