Sustainable Transportation Program
Update

Oak Ridge National Laboratory
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Vol.3, No.1 • February 2012

Advanced fuel cell technology surfaces with cost-savings and performance benefits

Successful multi-year collaborations with industry, universities, and other national labs have enabled the development and industry demonstration of an ORNL-developed technology for advancing next-generation fuel cells.

Several years of scientific study followed by assessment and scale-up work that began in 2007 have culminated in researchers establishing the viability of a novel nitriding approach in conjunction with an ORNL-developed ferritic stainless steel alloy for use with thin stamped bipolar plates.

The design basis of the alloy, Fe-20Cr-4V, evolved from studies of protective nitride surface layer formation on more expensive titanium-base and nickel-base alloys to implementation in low-cost iron-base alloys. Unlike many conventional stainless steels, this ferritic alloy contains vanadium that during thermal treatment aids the formation of a protective nitride coating with properties that support both excellent corrosion-resistance and electric conductivity.

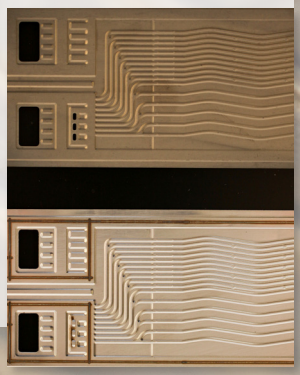
"With the unique coating properties, the thin stamped nitrided metallic bipolar plate provides a low-interfacial-contact and corrosion-resistant surface with no observed performance decline attributable to the plates," said ORNL team leader Mike Brady, Materials Science and Technology Division, summarizing findings from extensive studies of corrosion resistance, electrical properties, and more than 1000 hours of single-cell fuel cell evaluation under cyclic conditions.

In addition to results indicating performance comparable or better than current technologies, the alloy is much less expensive to manufacture than graphite, a material commonly used to form bipolar plates. Its thinness (less than 0.1 mm) also enables greater overall fuel cell power density.

"Because the plates are so thin compared to graphite, more can be added to the fuel cell stacks for high power density in automotive or other applications," said Mike. He explained that typically, one hundred or more bipolar plates are employed inside a proton exchange membrane fuel cell stack, the device that chemically converts energy from hydrogen into electricity. Each plate electrically connects the anode of one cell to the cathode of another to produce a useful voltage.

In 2011, General Motors (GM) Research Laboratories conducted manufacturing and fuel cell assessments using the ORNL-developed nitrided alloy, further supporting promising properties previously identified by ORNL and others. Using current GM stamping practices and plate design, the nitrided material was manufactured into a state-of-the-art automotive bipolar plate and found to be amenable to laser welding assembly. Under the GM relative humidity cycling, single-cell fuel cell performance evaluation (500-1000 hours of operation), the nitrided bipolar plates maintained low contact resistance and the proton exchange membrane exhibited only trace levels of metal ion contamination, consistent with good corrosion resistance under fuel cell operating conditions.

Mike is currently working with GM to complete a journal article on the test results, scheduled for publication in early 2012. Other ORNL researchers involved in the project include Energy and Transportation Science Division's Todd Toops and Josh Pihl, and MSTD's Peter Tortorelli, Karren More, Harry Meyer, and Phil Maziasz.



Close-up of bipolar plates made of ferritic alloy, nitrided variety (top) and non-nitrided.

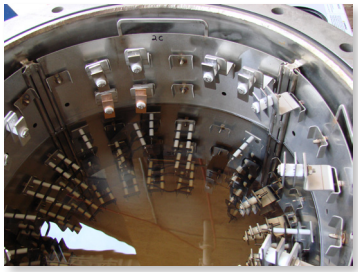
Results shared on compatibility of elastomers, plastics with higher ethanol fuel blends

Energy and Transportation Science Division's Mike Kass and Tim Theiss recently presented a Webinar lecture on the results of ORNL-led studies evaluating the compatibility of fueling infrastructure materials to test fuels representing aggressive formulations of ethanol-blended gasoline, ranging from 10 to 85 percent ethanol. Hosted by the National Renewable Energy Laboratory and advertised by the Petroleum Equipment Institute, the presentation was well received with more than 70 participants representing fueling dispenser, component, and materials manufacturers, and interested government agencies.

During the Webinar, participants learned that the intermediate levels of ethanol (10 to 17 percent) produced the highest volume swell for the majority of the elastomers. Fluid permeation decreased dramatically with higher ethanol concentration. For several specimens, exposure to 85 percent aggressive ethanol did not produce noticeable swelling though it was enough to extract plasticizers and cause embrittlement. In contrast, the majority of plastic materials were not as dramatically impacted with exposure to the test fuels, but a few did exhibit noteworthy changes. For instance, a nylon specimen shrank by 8 percent after drying, and the vinyl ester and polyester resins swelled to over 20 percent with exposure to blends containing 25 percent ethanol.

"The information may play a critical role in designing new infrastructure systems to handle intermediate levels of ethanol-blended gasoline," said Mike, adding, "The data will also help to advance the development of adequate retrofit kits for the existing infrastructure, which will enable higher levels of ethanol to be sold."

ORNL research efforts are in collaboration with National Renewable Energy Laboratory and Underwriters Laboratories, supporting the Intermediate Ethanol Blends Program funded by DOE's Office of Energy Efficiency and Renewable Energy's Biomass and Vehicle Technologies Programs. In addition to Mike and Tim, ORNL researchers who participated in the materials compatibility studies include Materials Science and Technology Division's Steve Pawel and Chris Janke.



During compatibility testing, materials specimens were exposed to the test fluid(s) in a large stainless steel tank with stainless steel hardware (stir chamber), then subjected to multiple tests after fluid exposure.

New truck illustrations designed to educate

To support the 21st Century Truck Partnership, Energy and Transportation Science Division's Tim LaClair is working with graphic artist Lindsey Marlar to update a series of frequently-used illustrations of energy loss categories and magnitudes for generic heavy and medium truck classes. The graphics are being revised to present a more accurate picture of efficiency improvement opportunities for technologies and, for the first time, operational practices such as driver influence upon fuel economy, combination trailers, etc. The truck energy diagrams were presented to the 21st Century Partnership and changes will be implemented prior to publication based on feedback from other members.

21st Century Truck Partnership is an industry-government collaboration among heavy-duty engine manufacturers, heavy-duty truck and bus manufacturers, heavy hybrid powertrain manufacturers, and four federal government agencies including the Department of Energy. The partners work cooperatively to develop a balanced portfolio of research aimed at achieving their research goals, coordinating their research activities as appropriate, and making effective use of the nation's research universities and national laboratories.

Employee Excellence

- During the 2011 Patent and Key Contributor Awards ceremony, Energy and Transportation Science Division's Bill Partridge and Jim Parks received dual recognition for developing fuel-in-oil (FiO) technology that was patented in 2010 then received the 2011 Federal Laboratory Consortium National Award for Excellence in Technology Transfer. The FiO technology was developed in a DOE-funded cooperative research and development agreement between ORNL and Cummins Inc. and has been licensed for commercial development to Da Vinci Emissions Services. ETSD's Sam Lewis and Maggie Connatser were recognized for their contributions to a patent related to Raman imaging of fingerprints. This patent was issued based on ORNL work, led by Chemical Sciences Division's Linda Lewis, which enables detection of fingerprints that could not be resolved with conventional methods.

- Environmental Sciences Division's Rebecca Efroymson, Yetta Jager, and Virginia Dale participated in a workshop in late 2011 on EPA's conceptual models, which diagram activities and potential impacts of biofuel feedstock production. These conceptual models were first developed for EPA's, "Biofuels and the Environment: First Triennial Report to Congress."

- In late 2011, a cross-directorate team filed invention disclosure S-124,305 and #201102745, "Novel Materials and Processes for Minimizing Core Losses in Stators." According to team members, the materials processes and unique stator design using novel grain oriented silicon steel will result in a significant reduction in core power losses in a motor stator when compared to conventional designs using stacked non-oriented steel sheets. In electric machines the stator iron functions as both mechanical support and return path for magnetic flux. Inventors include Energy and Transportation Science Division's John M. Miller, Curt Ayers, and Tim Burress, and Computer Science and Mathematics Division's Balasubramaniam Radhakrishnan.

Visitors & Events

Energy Partnerships Director Ray Boeman, left, with GM's Gary Smyth inside the Carbon Fiber and Composites Research Laboratory.

- ORNL hosted General Motors officials Gary Smyth and Jim Rainbolt on January 24 and 25. The guests toured numerous facilities at the main campus and NTRC to learn more about transportation-related research capabilities and collaborative opportunities in vehicle and fuel technologies, materials sciences, neutron sciences, high performance computing, and advanced manufacturing.

- Energy and Transportation Science Division staff hosted a visit by representatives of Ford Motor Company in December, providing an update on ongoing research and development funded by Ford and discussions on other opportunities for collaboration. The visit included tours of the FEERC engine research laboratories and the High Temperature Materials Laboratory, discussions with principal investigators, and briefings by ORNL leaders.

Do you have news or information you would like to share?

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