Technical Highlights September 2012

Archival Publication Highlights New Catalyst Insights Resulting from the Department of Energy (DOE)-Sponsored Oak Ridge National Laboratory (ORNL)-Cummins Cooperative Research and Development Agreement (CRADA) and Enabling Catalyst Advances Consistent with Improved Efficiency

A paper entitled "Local Ammonia Storage & Ammonia Inhibition in a Monolithic Copper-Beta Zeolite SCR Catalyst," by Xavier Auvray, William Partridge, Jae-Soon Choi, Josh Pihl, Aleksey Yezerets, Krishna Kamasamudram, Neal Currier, and Louise Olsson was recently published in *Applied Catalyst B: Environmental* (V126, pp. 144–152, http://dx.doi.org/10.1016/j.apcatb.2012.07.019); this work is the result of a collaboration between ORNL, Chalmers University of Technology, and Cummins Inc. and built primarily on the DOE-funded ORNL-Cummins CRADA. The paper provides new information regarding spatially distributed on-board ammonia (NH_3) utilization and inhibition in a Cu-Beta zeolite selective catalytic reduction (SCR) catalyst. Specifically, the NH_3 capacity is effectively saturated over the major portion of the catalyst used for SCR and dynamic inhibition conversion inflections are due to suitably fast NH_3 coverage buildup and thus occur to a greater extent at the catalyst front where high gas-phase NH_3 concentrations drive fast coverage buildup. These new insights have fundamental and practical relevance including enabling improved catalyst models, design tools, control and on-board diagnostic (OBD) strategies, and are thus supportive of the DOE objectives for improved efficiency and durability.

Bosch-led Consortium including ORNL/FEERC Wins Funding Opportunity Announcement (FOA) Award

DOE announced that a collaboration between Robert Bosch LLC, Clemson University's Center for Automotive Research, and ORNL's FEERC will receive $2.7M in funding to develop an oxygen-sensor-based technique for measuring EGR levels to a level of accuracy not currently possible. EGR is a critical technology for emissions control in compression-ignition engines and is a near-term technology for improving fuel efficiency in spark-ignited engines. The award was a result of collaboration among the three entities in response to a competitive DOE FOA. FEERC will provide experimental support to the partnership to validate modeling results and investigate sensor performance.

FEERC Research Explores the Fuel Economy Potential of Reactivity Controlled Compression Ignition (RCCI)

The first of its kind fuel economy estimates were completed for RCCI combustion in support of a high level DOE milestone. Experimental RCCI data was collected on a multi-cylinder light-duty engine to form an RCCI engine map. The map was then used in vehicle systems simulations to demonstrate modeled fuel economy improvements with advanced combustion as compared to a 2009 PFI gasoline baseline. The results showed greater than 15% improvement in modeled fuel economy was possible with RCCI/diesel multimode operation as compared to the PFI baseline.

ORNL Completes Field Experiments to Evaluate Acoustic Degradation in Heavy Foliage

A group of researchers, including Mike Kass, Charles Finney, and Stuart Daw, recently completed a series of field tests investigating the attenuation of sound in heavy foliage. This research took place on the ORNL reservation and consisted of measuring the acoustic spectrum of selected spectral frequencies and those emitted by a gasoline generator. Test sites included a monotype forest composed almost entirely of American sweetgum (*liquidambar styraciflua*), a mixed forest of hardwoods and conifers, and an open field (which served as a control). Five microphones (including two equipped with parabolic reflectors) were used to record the transmuted signals at distances ranging between 35m and 210m. This study represents the first attempt to correlate narrow spectral transmission in heavy foliage to foliage complexity and the results are expected to advance signal detection and identification in heavy foliage.

ORNL-Cummins CRADA Research Produces U.S. Patent on Rapid O_2 Measurements for Engine-Efficiency Applications

United States Patent No. 8,248,612, *Oxygen Concentration Sensors and Methods of Rapidly Measuring the Concentration of Oxygen in Fluids*, was issued August 21, 2012. The invention was developed by ORNL\FEERC research staff Jim Parks and Bill Partridge in a DOE-sponsored CRADA between ORNL and Cummins, Inc. and focuses on rapid oxygen measurement in engine intake and exhaust flows. Such measurement has broad applicability to enabling advanced engine efficiency; e.g., via assessing cylinder uniformity (fueling, breathing, etc..) and implementing nonuniformity mitigation strategies, EGR levels, combustion completion and misfire, implementing advanced control strategies, etc.

FEERC Researcher Invited to Contribute Fuel Material Compatibility Data as Part of White House Data Initiative

Mike Kass was invited by DOE to contribute fuel ethanol and polymer material compatibility data files as part of the White House Data Initiative. Data files covering physical properties (such as hardness, volume, and mass) of fueling infrastructure polymers to ethanol-blended gasoline were successfully submitted. This information (subsequently provided in an open format) was instrumental in allowing Underwriters Laboratories to develop an appropriate testing protocol for retrofit kits to be used on existing fuel dispensers. The data was also used by the fuel dispensing industry to confirm suspected material performance, which was then used to develop durable fueling components for use with ethanol-blended fuels.

Upgrade of FEERC Research Facilities Leads to Improved Research Capabilities with Advanced Combustion

The multi-cylinder high-efficiency clean combustion (HECC) engine test cell was upgraded from an eddy-current dynamometer to a motoring AC dynamometer. This upgrade will enhance the ability to conduct advanced combustion research at ORNL by allowing for motoring engine operation and increased control over transient engine experiments.

Invited Talks and Presentations

DOE Catalyst Research Highlighted at International Conferences

ORNL Research Staff Dr. Todd Toops, Dr. Jae-Soon Choi, and Dr. Bill Partridge recently presented technical results from several DOE-sponsored projects at international conferences; Dr. Toops at the 9th International Congress on Catalysis and Automotive Pollution Control (CAPoC), August 29th–31st in Brussels, Belgium, and Dr. Choi and Dr. Partridge at the 7th International Conference on Environmental Catalysis (ICEC), September 2nd–6th in Lyon, France. Other FEERC staff significantly contributing to those presentations include Mr. Josh Pihl, Dr. Stuart Daw, Dr. Mi-Young Kim, and Dr. Ji-Hyung Yoo. The technical presentations covered diverse relevant automotive catalyst areas including NH_3 utilization over SCR catalyst, mechanistic insights to nitrous oxide (N_2O) selectivity over lean nitrogen oxide (NO_X) trap (LNT) catalysts, advanced catalyst formulation methodologies for improved sulfur tolerance and robustness, a unique diagnostic for rapid distributed temperature measurements, biodiesel impacts on SCR catalyst performance, lean-gasoline catalysis, and soot-oxidation kinetics in wall-flow particulate filters. These presentations resulted from DOE-sponsored research with a wide range of collaborative partners including Cummins Inc. (via CRADA), Navistar Inc., Michigan Technological University, Institute of Chemical Technology Prague and Chalmers University of Technology, and the University of Tennessee (UT). These conferences provide a unique opportunity to acquire critical feedback and exposure regarding these projects, and are an important tool for maximizing the benefit of DOE research funding.

FEERC Researcher Delivers Invited Presentation to UT Sustainable Energy Research Group
FEERC researcher Scott Curran was invited to give a presentation to the Sustainable Technology through Advanced Interdisciplinary Research (STAIR) at UT. Mr. Curran presented on how unique properties of renewable fuels can enable high efficiency internal combustion engines such as advanced combustion strategies like RCCI and octane optimization with spark ignition engines with ethanol fuel blends.

FEERC Researcher Delivers Invited Presentation at the 15th IEEE Intelligent Transportation Systems Conference
Andreas Malikopoulos presented a paper entitled "Optimization of Driving Styles for Fuel Economy Improvement," at the 15th IEEE Intelligent Transportation Systems Conference. The research presented was a driver's feedback system that employs visual instructions with the aim of optimizing a driving style in real time with respect to various factors. With this technology fuel economy can be improved by as much as 20%. Andreas chaired also the session entitled "Route Planning and Guidance."

Renewable Fuel Effects on RCCI Research Presented at American Society of Mechanical Engineers (ASME) Internal Combustion Engines Fall (ICEF) Conference in Vancouver
FEERC researcher Scott Curran presented a paper investigating the role that renewable fuels can play in increasing the load range of RCCI as compared to conventional petroleum based fuel at the ASME ICEF conference. Mr. Curran also served as a session organizer for the meeting for the advanced and fundamental combustion sessions.

ORNL Researcher Delivers Presentation on Ethanol Optimized Engines at DOE Headquarters
At a seminar at DOE headquarters, Jim Szybist delivered a presentation entitled “Overview of Engine Efficiency Improvements Enabled by High Octane of Ethanol Fuel Blends.” The potential of high octane fuels, particularly ethanol, to increase engine and vehicle efficiency is currently receiving a significant amount of attention from industry. The purpose of this presentation was to highlight ORNL’s past and ongoing work in this area and to discuss additional challenges and opportunities associated with moving towards an ultra-high octane fuel containing upwards of 51% ethanol. Those in attendance included Ed Owens, Steve Goguen, Kevin Stork, Steve Przesmitzki, and Ken Howden.

RCCI Mapping and Drive Cycle Fuel Economy Modeling Presented at Advanced Combustion & Emissions Control (ACEC) Tech Team Meeting
FEERC researcher Scott Curran presented recent RCCI mapping results and fuel economy modeling to the US DRIVE ACEC Tech Team’s September meeting. The mapping and fuel economy modeling are related to two high level DOE Joule milestone competed for the Vehicle Technologies Program.

FEERC Researcher Delivers Invited Presentation at International Meeting in Sweden
Robert Wagner presented on the topic of “Reactivity Controlled Compression Ignition Combustion in Multi-Cylinder Engines” to an invitation only gasoline compression ignition combustion session at the SAE Powertrain Fuels and Lubricants conference in Malmo, Sweden. This presentation highlighted on-going research at ORNL under the direction of Scott Curran. Dr. Wagner also presented a literature survey on the impacts of fuel properties on diesel and advanced combustion processes. That research was co-authored by FEERC staff member Scott Sluder.

Awards

FEERC Researcher to Chair SAE’s Land and Sea Operating Group

On September 28th, the SAE President and Board of Directors confirmed Scott Sluder's election as the 2013–2014 Chairman of the Land and Sea Operating Group and accordingly appointed him as a member of the Engineering Meetings Board. The Engineering Meetings Board is charged with the development, collection, and distribution of technical information of value to SAE members and other mobility practitioners. The Land and Sea Group is one of two operating groups of the Engineering Meetings Board and is responsible for all aspects of SAE's worldwide technical meetings in the area of surface transportation. A second operating group, the Air and Space Group, is similarly responsible for technical meetings dealing with non-surface transportation. Mr. Sluder's term as Chairman will begin on January 1, 2013, and continue through 2014, after which he will continue to serve for an additional two years as the past Chairman.

FEERC Research Wins ORNL Poster Session

Andreas Malikopoulos' poster entitled "Intelligent Advanced Propulsion Systems," was among the four winners in the annual Laboratory Directed Research and Development (LDRD) poster session for projects that are to be completed by the end of the fiscal year.