Technical Highlights
February 2013

Cummins and the Oak Ridge National Laboratory (ORNL) Teams Works to Enable Super Truck Efficiency Goals

ORNL/Fuels, Engines, and Emissions Research Center (FEERC) staff member Bill Partridge and the Oak Ridge Associated Universities (ORAU) Post-Doctoral Research Associates Rodrigo Sanchez-Gonzalez and Jon Yoo performed on-site measurements on Cummins' Super Truck engine at a development facility in Columbus, Indiana, December 10–14, 2012. The Cummins team members were led by Rick Booth, Akshaya Srinivasan, Aniket Waghchaure, and David Koeberlein. The work involved spatiotemporal exhaust gas recirculation (EGR) distribution measurements to assess the numerical design tools used for development of Cummins' clean-sheet high-efficiency Super Truck engine system. The multiplex laser-based EGR Probe was used for EGR mapping measurements; the EGR Probe was primarily developed in a separate Department of Energy (DOE)-sponsored Cummins-ORNL Combustion Cooperative Research and Development Agreement (CRADA), where it has also been extensively applied for engine design and control insights. A multiplex instrument was used for the first time in this campaign allowing simultaneous measurements from four separate EGR Probes positioned at different locations in the engine system, which profoundly enhances how extensively the system can be mapped. Indeed, via this efficient multiplex approach the primary campaign objectives were realized a day early allowing time for additional engine-system assessment through various transients. Moreover, because such transients can involve dynamics on multiple time scales, the analysis approach was modified in the field to allow resolution of EGR variations from fast crank-angle scale to longer tens-of-seconds-to-minutes scale. The Cummins-ORNL team is analyzing the data from this campaign to assess engine hardware, the numerical design tools and the EGR Probe measurements themselves. The team is planning for a follow-on campaign in mid-2013. Through this and similar CRADA work, DOE and Cummins are enabling both near- and long-term efficiency, durability and cost advances, broadly beneficial to the United States (U.S.) and world consumers, manufacturers, economies, and climate.

ORNL and Ford to Partner in Investigating the Potential of High-Octane Fuels

Ford has agreed to partner with ORNL's FEERC to investigate the efficiency benefits offered through the use of high-octane-rating fuels. Ford has agreed to supply a state-of-the-art 1.6L, 4-cylinder Ecoboost engine along with its associated control system and technical support to the project. ORNL staff will use the engine in a DOE-funded project to investigate potential efficiency benefits that are enabled through the use of high-octane fuel formulations. Knock resistance, which is usually characterized by the fuel's octane rating, is a key characteristic that can limit the degree to which engine downsizing and downspeeding can be used in designing new vehicles. The use of high-octane fuels can enable efficiency increases both in the engine as well as at a system level in the vehicle. Ford and ORNL have recently completed an agreement for the transfer of the engine and delivery of the engine is expected in March.

ORNL Visiting Researcher Invited to give Presentation at Cummins Technical Center

Maria Pia Ruggeri made an invited presentation titled "Role of NO Oxidation to NO_2 in SCR Reactions" to Cummins' Catalyst Technology Group on February 8th, in Columbus, Indiana. Ms. Ruggeri is a Ph.D. student of Professors Enrico Tronconi and Isabella Nova at the Politecnico di Milano in Milan, Italy, and is currently on a six-month appointment as a Visiting Student Researcher with ORNL/FEERC where her mentors are Bill Partridge and Josh Pihl; her work is part of an informal collaboration between the two groups focused on advancing mechanistic understandings of automotive selective catalytic reduction (SCR) catalysis, a topic which is relevant to several DOE programs at ORNL including Cross-Cut Lean

Exhaust Emissions Reduction Simulations (CLEERS). Ms. Ruggeri's presentation was hosted by Dr. Aleksey Yezerets, Director of Catalyst Technology, and was attended by approximately 35 Cummins technical staff from their various facilities around the country who attended in person and via teleconference.

Research Shows Potential New Catalyst Concept to Enhanced Low Temperature Performance

A journal publication demonstrates the potential of a new catalyst concept to enhance the low temperature performance of automotive oxidation catalysts: Mi-Young Kim, Jae-Soon Choi, Todd J. Toops, Eun-Suk Jeong, Sang-Wook Han, Viviane Schwartz, and Jihua Chen, "Coating SiO_2 Support with TiO_2 or ZrO_2 and Effects on Structure and CO Oxidation Performance of Pt Catalysts," pp. 88–103 in *Catalysts*, **3**(1), March 2013. The results show that both excellent low temperature activity and durability of Pt-based oxidation catalysts can be achieved by surface modification of high surface area SiO_2 supports with TiO_2 and ZrO_2. This research was done in collaboration with the Center for Nanophase Materials Sciences at ORNL and Chonbuk National University in Korea.

Invited Talks and Presentations

Invited Seminar at Bredesen Center

Andreas Malikopoulos gave a seminar at the Bredesen Center for Interdisciplinary Research and Graduate Education entitled "Reverse-Engineering the Brain for Reproducing Intelligence in Applications Related to Energy and Transportation." In this talk, he highlighted current research efforts on developing mathematical decision-making models for making machines that can learn and truly think and thus dramatically impact the solution in problems related to energy and transportation.

Presentation on Mobile Source Air Toxics from Heavy-Duty Trucks

John Storey presented at the 2013 CRC Mobile Source Air Toxics Meeting, Sacramento, California, on February 5–6, 2013. His paper discussed measurements of air toxics from MY 2006-2012 heavy-duty trucks that were made with the Texas Transportation Institute (TTI) at their large environmental chamber in Bryan, Texas. Cold starts and hot starts at 30°F and 90°F were performed and formaldehyde, acetaldehyde, and several other aldehydes were measured and then compared with an earlier ORNL study of idling trucks (MY 1992–2000) done in an environmental chamber. The newer truck air toxic emissions displayed a reduction of between 75% and 99% over the old trucks in the previous study.

ORNL, the NREL, and Ford Research Highlighted at 2013 National Biodiesel Conference and Expo

Todd J. Toops (ORNL) and Bob McCormick (NREL) gave invited presentations at the 2013 National Biodiesel Conference in a session that was dedicated to their collaborative effort with Ford. The research highlighted the impact of trace metal impurities (Na, K, and Ca) on the end-of-life functionality and mechanical properties of emissions control devices. This effort focused on the light duty application and employed the Ford aftertreatment system that includes a diesel oxidation catalyst (DOC)/SCR/diesel particulate filter (DPF) arrangement. The long-term introduction of the metal impurities as well as the evaluation of the entire aftertreatment system on a Federal Test Procedure (FTP) drive cycle was performed, followed by the evaluation of the performance and a complete materials characterization of the metal location and chemical nature. The results show that the emissions control system was durable and able to meet the 2010 emissions standards at 150,000 miles (based on equivalent metal exposure and thermal cycling), but that some deactivation did occur of both the DOC and the front of the SCR relative to the base case.

FEERC Researchers present at DOE Advanced Combustion Meeting at Sandia National Laboratories

FEERC researchers Jim Szybist and Scott Curran presented recent research and activities at the 2013 Spring Advanced Engine Combustion Working Group review meeting at the Sandia National Laboratory's Combustion Research Facility in Livermore, California. Jim Szybist presented an overview of the recent Society of Automotive Engineers (SAE) High Octane Fuels symposium to give the researchers in the group a perspective with regards to the current trends in high octane fuel policy and implementation including the consideration of a super-renewable premium fuel using high levels of ethanol. Scott Curran presented findings related to a high level DOE milestone in which the fuel economy potential of a light-duty vehicle using a combination of diesel combustion and reactivity controlled compression ignition using vehicle systems level modeling with experimental engine data.