March 2015 Highlights

ORNL Fuels, Engines, and Emissions Research Center

TECHNICAL HIGHLIGHTS

The Oak Ridge National Laboratory (ORNL) Report Documents High-Octane Fuel Effects on Legacy Vehicle Acceleration and Fuel Economy

An ORNL Report prepared this month shows that legacy Flex Fuel Vehicles (FFVs) can realize an acceleration boost when fueled with high-octane midlevel blends. The experiments included a non-FFV with a turbocharged direct-injection engine which similarly demonstrated improved acceleration and also realized up to a 4.6% efficiency boost with high-octane fuel. Three of four FFVs showed significant acceleration performance improvement when fueled with high-octane E30 rather than regular E10. Fuel economy for the large-displacement, normally-aspirated FFVs largely tracked the energy density of the fuel. However, when high-octane E15 was evaluated in a vehicle with a small turbocharged gasoline direct-injection (GDI) engine, the acceleration performance compared to regular E0 gasoline was more significant and thermal efficiency improvement on the drive cycles was observed. For the turbocharged GDI car on the high-load US06 cycle, the E15 fuel achieved within 1% of volumetric fuel economy parity, indicating a 4.6% thermal efficiency improvement. The Department of Energy (DOE) is supporting research to investigate the potential fuel economy benefits of high-octane fuels in downsped, downsized, boosted engines. Marketing a high-octane fuel such as E30 to (over 17 million) FFV owners as a performance fuel today may enable greater ethanol utilization in the near term, and could help establish the refueling infrastructure to enable manufacturers to build dedicated vehicles designed for a high-octane midlevel ethanol blend in the near future. Experiments were supported by the Bioenergy Technology Office and Vehicle Technologies Office (VTO) at DOE.

Fuels, Engines, and Emissions Research Center (FEERC) Leads Multi-National Laboratory Stakeholder Meeting on New Virtual Vehicle Initiative

FEERC Director Robert Wagner led a multi-national laboratory team in the development and execution of an industry stakeholder meeting to form a high-level consensus on stakeholder interest, needs, and the value of the development of a full 3D high-fidelity virtual vehicle simulation environment. This initiative has become known as the Virtual Vehicle Initiative across DOE and industry. The meeting included 24 attendees from 10 companies, 10 attendees from 6 national laboratories, and 4 attendees from DOE. ORNL attendees included Sreekanth Pannala, Ron Graves, and Johney Green. Sreekanth Pannala helped with planning the meeting and co-led the interactive portion of the meeting. DOE attendees included Deputy Assistant Secretary of Transportation Reuben Sarkar (by phone). A summary report of the meeting will be available in the coming weeks.

New Student Internship Interaction with Clemson University's Automotive Engineering Master's Program

FEERC welcomed new student researcher, Nandini Gowda Kodebyle Raju, who will be working with cycle-simulations for advanced engine air handling systems. Nandini sought out the opportunity to serve the required internship as part of the Clemson Automotive Engineering Master's program at ORNL. The unique graduate program at Clemson is dedicated to automotive engineering where students learn in an innovative research-and-educational program that focuses on the vehicle and its infrastructure from a systems-integration perspective. Currently more than 200 students are pursuing graduate degrees

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in automotive engineering. The ORNL internship is being executed through the Oak Ridge Associated Universities (ORAU) Advanced Short-Term Research Opportunity (ASTRO) program and Nandini is the first such student to serve their internship within FEERC.

ORNL Demonstrates the Path of 15% Fuel Economy Benefit of Long-Haul Truck Hybridization
Zhiming Gao, Tim LaClair, Stuart Daw and David Smith reported a fuel savings potential for long-haul truck hybridization at the 2015 Transportation Research Board (TRB) annual meeting, January 2015, in Washington, D.C. The results demonstrate that long-haul hybrids with significant aerodynamic drag and rolling resistance reduction can minimize heavy-load demand, recover more kinetic energy, and leverage engine-off operations so as to significantly reduce the engine energy losses. The hybrid powertrain configuration could increase the fuel economy by more than 15% relative to the conventional powertrain with the same aerodynamic and rolling loss reductions. The fuel consumption reduction could lead to a large net savings in annual fuel cost because of the extremely high annual mileage and fuel consumption of long-haul trucks. The paper has been recommended by TRB committee to publish in the *Transportation Research Record Journal*. The research is funded by DOE VTO program. ORNL VTO program managers are David Smith and Perry T. Jones.

ORNL Team Completes Neutron Imaging Fuel Injection Campaign with Heated Spray Chamber
Eric Nafziger, Derek Splitter, Alex Pawlowski, and Todd Toops led an intensive effort to complete and commission a new closed-loop fuel injection system with heated spray chamber for use in a neutron imaging beamline at ORNL's High Flux Isotope Reactor (HFIR). The effort is focused on the intra-nozzle fluid dynamics that occur in GDI systems, with a specific focus on identifying the time and location of cavitation events. The sophisticated system is designed to operate with commercial and prototype injectors and deliver fuel to the injectors at rail pressures up to 150 bar. The spray chamber can be operated at absolute pressures as low as 0.2 bar, i.e. sub-ambient, and currently has a maximum pressure of approximately 4 bar and can be heated over 100°C even while flowing 14 L/min purge gas. These conditions are necessary to avoid condensation of the fuel in the chamber, since condensed fuel will block neutron flux. In collaboration with General Motors (GM), ORNL was provided a single-hole injector with the same internal dimensions of a 6-hole injector commercial-intent stepped-valve covered orifice (VCO). With the help of neutron scientists Hassina Bilheux and Louis Santodonato, this system was operated continuously for 120 hours at HFIR, and relied on an additional team of FEERC researchers—Maggie Connatser, Charles Finney, and John Thomas—to oversee the operation and ensure the system was working properly. At an injection rate of 10 Hz, approximately 1 million injection events are compiled to capture a 7 millisecond (ms) composite injection sequence (1 ms before injection, 1.2 ms injection, 4.8 ms after injection). In the initial analysis of the neutron images it is possible to see both internal injector motion and fluid movement within the injector. Just inside the nozzle area, a marked difference in fluid density is also observed during the injection event, indicating vaporization of the fluid and possible cavitation. More detailed analysis will be forthcoming.

FEERC Research Led to Improved Fundamental Understanding of Automotive Oxidation Catalysts Being Developed
In collaboration with a South Korean synchrotron-based materials research team, FEERC researchers co-authored a paper which provides fundamental insights into the properties of a novel class of catalytic materials being developed in the Center for automotive emission control applications. The team investigated changes in the local structure of platinum particles when titania or zirconia addition is added to silica supports. The obtained structure information helped the researchers to explain the catalytic performance enhancement observed with the oxide addition and develop strategies to further optimize catalyst structures. Reference: *Eun-Suk Jeong, Chang-In Park, Zhenlan Jin, In-Hui Hwang, Jae-Kwan Son, Mi-Young Kim, Jae-Soon Choi, and Sang-Wook Han, "Temperature-dependent local structural properties of redox Pt nanoparticles on TiO2 and ZrO2 supports," pp. 971–983 in Catalysis Letters, **145**(3), March 2015.*

HIGH-LEVEL OR NOTEWORTHY VISITS

Robert Wagner visits with Union of Concerned Scientist and Advanced Research Projects Agency-Energy (ARPA-E)

FEERC Director Robert Wagner serves on the steering committee and FY2015 planning team for a new multi-national laboratory research initiative on the co-optimization of fuel and engine technologies to significantly reduce greenhouse gas emissions. This initiative has become known as the Optima. Robert traveled to Washington, D.C. with the National Renewable Energy Laboratory (NREL) lead to discuss this

initiative with the Union of Concerned Scientists and ARPA-E. This topic will be presented to DOE Secretary Moniz and other high level government and laboratory officials at the DOE Big Ideas Summit in April. FEERC has significant participation in this initiative including leadership and supporting roles by Jim Szybist, Tim Theiss, Brian West, and Scott Curran.

FEERC Hosts Los Alamos National Laboratory Scientists to Investigate Novel Sensors in Real Engine Exhaust via the National Transportation Research Center (NTRC) User Facility Program
Scientists from Los Alamos National Laboratory visited ORNL to study the performance of their novel engine exhaust sensor technology on ORNL's lean-burn GDI engine. The study was conducted under the NTRC User Facility program at ORNL. Multiple mixed potential sensors for measuring ammonia, oxides of nitrogen (NOx), and hydrocarbons were simultaneously evaluated in the engine exhaust for understanding the response of the sensors to different engine operating conditions. The NOx and hydrocarbon sensors could quantitatively track concentrations in the engine exhaust and the ammonia sensor showed excellent sensitivity over concentrations ranging from 10–100 ppm. A prototype ammonia sensor was also evaluated on an automated flow reactor to collect calibration curves and quantify sensor cross-sensitivities. All three of the sensors show promise for various exhaust emissions sensing applications.

INVITED TALKS AND PRESENTATIONS

AWARDS

OUTREACH